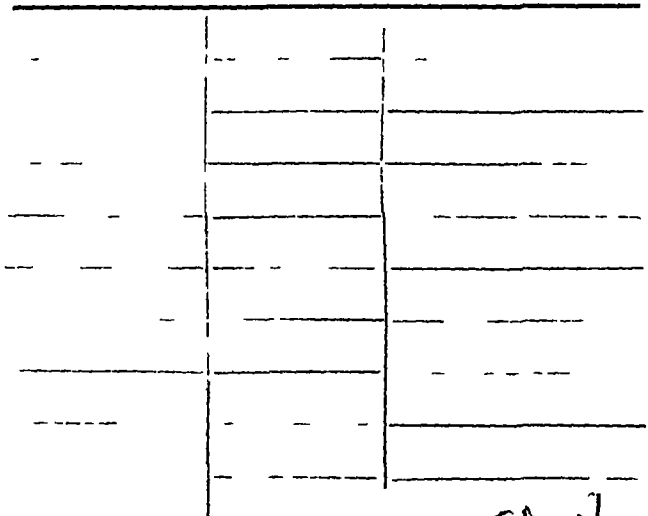

SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Report of the Secretary, Sugar Bureau)

1919-20

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1920

Since the retirement of Mr. G. A. Gammie at the end of September 1919 no permanent arrangement has been made to fill up the post of the Imperial Cotton Specialist. No report of that officer is therefore to be found in this volume.

The Report of the Secretary of the Sugar Bureau, being not exactly of a scientific nature, has been published as an appendix.

SIMLA,
The 28th September, 1920.

S. MILLIGAN,
Director, Agricultural Research Institute, Pusa.

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Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Report of the Secretary, Sugar Bureau)

1919-20

REPORT OF THE DIRECTOR.

(S. MILLIGAN, M.A., B.Sc., AND G. S. HENDERSON, N.D.A., N.D.D.)

I. CHARGE AND STAFF.

Charge. Mr. G. A. D. Stuart, I.C.S., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 23rd October, 1919, and Mr. J. Mackenna, C.I.E., I.C.S., from the 24th October, 1919, to the 30th April, 1920. On the transfer of Mr. Mackenna to Burma as Development Commissioner, Dr. E. J. Butler, M.B., F.L.S., held charge from the 1st May till he was relieved by Mr. S. Milligan on the 18th June, 1920.

Dr. E. J. Butler held the post of Joint Director of the Institute until the close of the year, but subsequently proceeded on leave, Mr. G. S. Henderson, Imperial Agriculturist, relieving him of his duties as Joint Director.

Staff. Dr. W. H. Harrison proceeded on leave for 18 months from 1st May, 1920, when Dr. J. Sen, M.A., PH.D., Supernumerary Agricultural Chemist, assumed charge of the duties of Imperial Agricultural Chemist. Dr. Sen's deputation under the United Provinces Government terminated on the 3rd December, 1919.

Mr. A. Howard, C I.E., M.A., and Mrs. Gabrielle L. C. Howard, M.A., Imperial Economic Botanists, went on leave from the 26th November, 1919. Mr. G. P. Hector, M.A., B.Sc., Economic Botanist to the Government of Bengal, has officiated as Imperial Economic Botanist since the 20th December, 1919.

Mr. J. H. Walton, M.A., B.Sc., Assistant Agricultural Bacteriologist, has been appointed to act as Imperial Agricultural Bacteriologist from the 11th April, 1920, the date from which Mr. C. M. Hutchinson, C.I.E., B.A., proceeded on leave for 18 months. Mr. N. V. Joshi, M.Sc., B.A., L.Ag., First Assistant to the Imperial Agricultural Bacteriologist, acts as Assistant Agricultural Bacteriologist from the same date.

Dr. F. J. F. Shaw, Second Imperial Mycologist, has been on 11 months' leave from the 5th February, 1920.

Mr. Wynne Sayer, B.A., acted as Imperial Agriculturist up to the 4th January, 1920, when the permanent incumbent, Mr. G. S. Henderson, resumed charge on return from leave.

At the close of the year under report, Mr. J. F. Dastur, M.Sc., Supernumerary Mycologist, was still on deputation in England for training.

Mr. Afzal Hussain, B.A., M.Sc., Supernumerary Entomologist, was transferred as Entomologist to the Punjab Government on the 16th September, 1919.

Mr. W. A. Davis, B.Sc., A.C.G.I., Indigo Research Chemist, was on leave from the 11th October, 1919, to the 25th April, 1920.

Dr. A. P. Jameson, who has been appointed Protozoologist at Pusa, joined his duties on the 17th October, 1919.

Subsequent to the close of the year under report, Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, died at Mussoorie on the 20th August, 1920, after a serious operation. His death is a serious loss to the Institute and the Indian Agricultural Service.

II. Work of the Institute.

Scientific Work. The scientific work of the Institute during the year is described in the reports of the various sectional heads. A description of much of the work has already appeared in the form of Memoirs and Bulletins. The following is a summary of some of the items of more immediate importance.

Agricultural Section. The permanent experiments were continued on the lines of former years and the usual collaboration in field experiments with the other Sections of the Institute. The general farm area has been organized so as to provide a large-scale test of the maintenance of soil fertility under a double cropping system without irrigation, the principal crops being used as food for the dairy stock and consumed on the farm.

Data regarding the economics of "power" cultivation and the comparative value of various rotation crops are being collected.

The success of the cross-breeding experiments with cattle, so far as the first cross is concerned, is now assured.

The results of the combined cattle-breeding and fodder-raising experiments are clear on two important points, *viz.*,—

(1) that, for the production of milk, it is possible by crossing with an imported breed of high pedigree to improve on the milk outturn per head of the Montgomery cattle purchased in the Punjab, to the extent of at least 100 per cent.;

(2) that, where conditions permit, it is possible by the use of power on a fairly large scale to greatly reduce the production-cost of fodder.

It is now clear that the cost of production of milk for the large towns could be largely reduced by the breeding of cross-bred cows for the special purpose of milk production and the growing of cheap fodder on the lines adopted at Pusa.

Chemical Section. As recommended by the Conference of Agricultural Chemists, an investigation into the methods of analysis of nitrogen and phosphoric acid in manures and fertilizers has been undertaken by the Chemical Section. The important investigations regarding the retention of phosphoric acid in calcareous and non-calcareous soils reached a stage which enabled Dr. Harrison to submit the result for publication. The work on windrowing of sugarcanes started at Peshawar was continued at Pusa where it was found that the canes were capable of being windrowed under conditions of temperature much higher than those obtaining in the North-West Frontier Province. The question as to whether the roots of certain crop plants excrete toxic substances, and the comparative effect of ammonium sulphate as a manure for paddy used alone and in combination with green manures, formed some of the other important investigations made by this Section.

Botanical Section. Botanical work on wheat, indigo, linseed, tobacco, *patwa* (*Hibiscus cannabinus*) and safflower has been continued. In addition to this, work on rice and jute receives mention in the report of the Officiating Economic Botanist. Reports from the United Provinces indicate that some of the new Pusa wheat crosses sent out for trial may prove even higher yielders than the well established Pusa 12, showing an improvement in the direction of a stronger straw and better grain-holding properties. Botanical work on indigo was confined mainly to a continuation of observations on plants grown in drained and undrained lysimeters, to the monthly examination of roots, and to seed selection. Definite results have been obtained from the work on linseed, indicating the lines on which improvement of the Bihar varieties must proceed.

The Officiating Economic Botanist, in collaboration with the Fibre Expert to the Government of Bengal, continued the investigations into "chlorosis" in jute which promise to have important practical results in eliminating this danger to the Bengal jute crop.

The Mycological Section was short-handed during the greater part of the year owing to the absence of two of the superior staff. The work on the black band disease of jute, rot in potatoes during storage, and on the diseases of fruit in Kumaon have, however, yielded important results. Diseases of cereals have been under investigation and considerable progress has been made in the enquiry which is likely to extend over several years. Observations at Lyallpur of the root-rot of cotton have led to the conclusion that this disease which occurs sporadically in Northern and Western India is a non-parasitic one and is associated with some unknown soil condition which will require special study.

Entomological Section. In additi n to systematic work on insects, the Entomological Section continued the investigation of the relative immunity of varieties of cotton from bollworm attack, of borer pests of sugarcane, rice and other cereals, and of other agents of damage to these crops which produce effects similar to those caused by borers. The Imperial Entomologist, in emphasizing the importance of the study of the stem borers, estimates that the average loss of sugarcane in India through the action of borers amounts to 10 per cent. of the total crop. Considerable material has been accumulated regarding insect pests of fruit trees. The results of the prolonged experiments and the details of the successful methods on the storage of grain against insect attack have been fully described in a paper by Mr. Fletcher and Mr. C. C. Ghosh. Further work on pests of stored grain was mainly directed to finding whether there is any infestation in the field and, if so, to what extent. Lac and sericulture also continued to engage the attention of this Section.

Pathological Entomological Section. On the conclusion of his deputation to investigate the mosquito repellents, the late Mr. Howlett worked on the effects of alkaloidal poisons on rats and of X-rays on mosquito larvæ in collaboration with Captain Barnard of the Colaba Hospital.

Attempts were also made to discover the insect-carrier of a short period fever which was seriously impairing the efficiency of ship's crews in the Bombay Docks. At the time of his death Mr. Howlett was engaged on a survey of flies in the Punjab and the North-West Frontier Province in connection with the transmission of surra amongst camels.

Bacteriological Section. A large amount of work on nitrification and fixation of nitrogen has already been done by the Bacteriological Section. During the year under report, investigations were carried out regarding the nitrification of cow-dung, cow-urine and sheepfold manure, along with their effects on plant growth. The losses of nitrogen during the storage of these manures are being further investigated. A study of the wide variations in the accumulation of nitrate during the decomposition of various oil-cakes tends to the conclusion that these are intimately connected with the carbohydrate-nitrogen ratio of the cakes, the oil content having apparently very slight influence on nitrification. A comparison of the nitrogen content of soil under fallow and growing crops showed that not only the nitrate but also the organic nitrogen content of the cropped plots were lower than those of the fallow plot. Further work on the sterilization of water by the new sterilizer (electro-chlorogen), mentioned in last year's report, was continued.

Protozoological Section. Dr. Pringle Jameson, who joined his appointment on the 17th October, 1919, has taken up the work on the pebrine disease of silkworms from the point where Mr. Hutchinson, who initiated the investigations, left off.

The work done by the *Indigo Section* is published in a special series of Indigo Publications started by the Institute. A separate annual report has, therefore, not been considered necessary.

Training. The number of post-graduate students under training at the Institute, during the year, are

given below. In addition, short courses have been given in sericulture.

	Number of students
General Agriculture	3
Agricultural Chemistry	1
Mycology	2
Economic Entomology	1
Agricultural Bacteriology	1
Sericulture	5
TOTAL	13

In addition, Mr. T. P. Padmanabha Pillai, Mycologist, Travancore State, spent a month in the Mycological Laboratory, and a stipendiary student from Ajmer-Merwara underwent a training in general analytical methods for three months in the Chemical Laboratory. Two students sent from the Agricultural College at Sabour were also given instruction in sericulture not amounting to a regular course.

III. PUBLICATIONS.

Six Memoirs, nine Bulletins, one Indigo Publication, and three pamphlets were issued during the year, while 32 publications were in the press at the close of the year.

The proceedings of four conferences, *viz.*, the Eleventh Meeting of the Board of Agriculture, the Second Meeting of Mycological Workers, the First Meeting of Agricultural Chemists and Bacteriologists, and the First Meeting of Veterinary Officers, were also brought out during the year, and the Report of the Proceedings of the Third Entomological Meeting, an octavo volume of 1,138 pages of print and 182 plates, was still in the press on the 30th June, 1920.

The issue of the "Agricultural Journal of India" every two months, instead of every quarter, has further stimulated its circulation, and, with the commencement of the New Year, it is proposed to further increase the print order by 250 copies to meet the growing demand.

IV. Accounts.

The total expenditure during the financial year ending the 31st March, 1920, was Rs. 6,59,343 as against Rs. 6,06,640 during the previous year. The details are given below:—

	Rs.
General expenditure on the Institute (including the Office of the Agricultural Adviser and Director)	2,61,236
Chemical Section	39,856
Mycological Section	45,983
Entomological Section	54,089
Pathological Entomological Section	31,259
Bacteriological Section	39,077
Botanical Section	45,261
Agricultural Section	87,381
Indigo Research Section	51,838
Protozoological Section	3,363
Total	6,59,343

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special agricultural experiments were as follows:—

	Rs.
For investigation of anti-scorbutic and anti-beriberi properties of sun-dried vegetables	2,000
Cost of fencing materials	993
Entertainment of visitors during motor tractor demonstrations	747
Pebrine experiments	246
Cost of oil for surra experiments	500
Apparatus and appliances for the Mycological Section at Pusa	1,409
Experimental cotton cultivation by the Imperial Cotton Specialist, Poona	1,000
Mosquito experiments at Pusa	316
Pay of a Veterinary Assistant	541

The gross receipts during the year from the sale of farm produce, milk, publications of the department and other articles amounted to Rs. 36,221 as against Rs. 21,403 last year.

V. Conference.

The Eleventh Meeting of the Board of Agriculture in India was held at Pusa from the 1st to 6th December, 1919, under the presidency of Mr. James Mackenna, C.I.E., I.C.S. The meeting was attended by 49 members and 27 visitors, the latter including the Hon'ble Sir Claude Hill, Member-in-charge of the Department of Revenue and Agriculture, Government of India, the Hon'ble Mr. R. A. Mant, Secretary to the Government of India, Department of Revenue and Agriculture, and the Members of the Indian Sugar Committee.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. HENDERSON, N.D.A., N.D.D.)

I. CHARGE.

Mr. Wynne Sayer held charge of the post of Imperial Agriculturist till the 4th of January, 1920, when the permanent incumbent took over charge.

Khan Sahib Mohammed Ikramuddin was appointed to the post of Assistant to the Imperial Agriculturist on 13th August, 1919.

Khan Bahadur Judah Hyam retired from service on 25th August, 1919, and Mr. L. S. Joseph was appointed as Cattle Superintendent.

II. GENERAL.

An important part of the work of the Imperial Agriculturist is to act as liaison officer to the various provincial agricultural authorities in India. During the past year little in this direction was possible, Mr. Sayer being employed on the Indian Sugar Committee during most of the year and during the remaining months the writer has, among other general work, been occupied with a scheme for motor tractor trials and proposals for an Agri-Irrigation Research Institute. A number of tours were, however, undertaken in connection with these proposals. A full scheme was drawn up for the proposed Irrigation Research Institute in consultation with Mr. T. R. J. Ward, Inspector-General of Irrigation, and Mr. Roberts, of the Punjab Agricultural Department.

A consultation was held with Mr. Smith, the newly appointed Imperial Dairy Expert, regarding the place of the Pusa herd in the general scheme for the improvement of cattle-breeding in India. In the new dairy schemes being worked out for various provincial departments the agricultural part of the programme will be drawn up by the Imperial Agriculturist.

The second and fourth classes of agricultural students were examined at Lyallpur, Punjab. These students were found to be of a useful and practical type, and show promise of being of great value to the future agricultural development of the Punjab.

III. Publications.

A Bulletin entitled "Practical notes on Salt Land Reclamation" was issued during the year. The Guide to the farm at Pusa was brought up to date, and the preliminary work for a Bulletin on details and costs of the different farm crops at Pusa was completed. Various notes and reviews for the "Agricultural Journal of India" were completed. A large number of agricultural enquiries from all parts of India were replied to.

IV. Training course.

While there is at present no definite post-graduate course in agriculture at Pusa, graduates are admitted to study farm practice and management of the dairy herd. Three students were admitted during the year under review.

V. Pusa Farm.

The farm is under the Imperial Agriculturist, and, as has been explained in former reports, consists of about 500 acres of arable land and 400 acres grazing in addition to a carefully prepared experiment area. The whole is laid out so as to permit of its being worked on up-to-date practical lines and operated with such western machinery and implements as are suited to Indian agriculture. The produce of the farm is used in the upkeep of the pedigree dairy herd. The whole concern is very cheaply run and is, from the strictly financial point of view, a good investment for Government.

The Season. The season was an abnormally dry one, the total rainfall amounting to 32·73 inches as against 60·19 inches for the previous year. Sowings went on intermittently during the scanty rainfall in the first three weeks

of June and were not completed till July. The pulse crop was consequently sown too late. The shortage of rainfall continued during the monsoon. Two inches of rain in October, however, facilitated the sowing of the *rabi* (winter) crop. Drought again intervened till February 1920 when rain saved the oat crop from total failure but was too late for straw. The *arhar* (*Cajanus indicus*) crop which was flowering at the time suffered a great deal and yielded disappointingly. The monsoon, though light, was not unfavourable to the maize grown for grain, but that grown for green fodder was much below normal.

The Pusa Farm is worked under a three-year 6-course rotation given below. The land is double-cropped, *i.e.*, two crops are taken off the same land annually.

	1st Year	2nd Year	3rd Year
Monsoon crop (*Kharif*) . .	Maize for silage and fodder	Maize for corn	Pulse green crop
Winter crop (*Rabi*) . . .	Oats . .	*Arhar* (*Cajanus indicus*)	Oats

Details are as follows:—

1st year's rotation. The land under maize is given 10 tons farmyard manure or 10 maunds oil-cake and is followed by oats in the *rabi*. During the year under report five fields aggregating 125 acres were put down under maize and *juar* (*Andropogon Sorgum*). The best yield was got from South Pangarbi field where 15 acres gave 220 maunds per acre of green fodder, the best yield of oats being 14½ maunds per acre from Brickfield No. 2.

The working cost for the year for both *kharif* and *rabi* crops in this year of the rotation amounted to Rs. 56-4* per acre and the return to Rs. 88-2, giving a working profit of Rs. 31-14 per acre for the year.

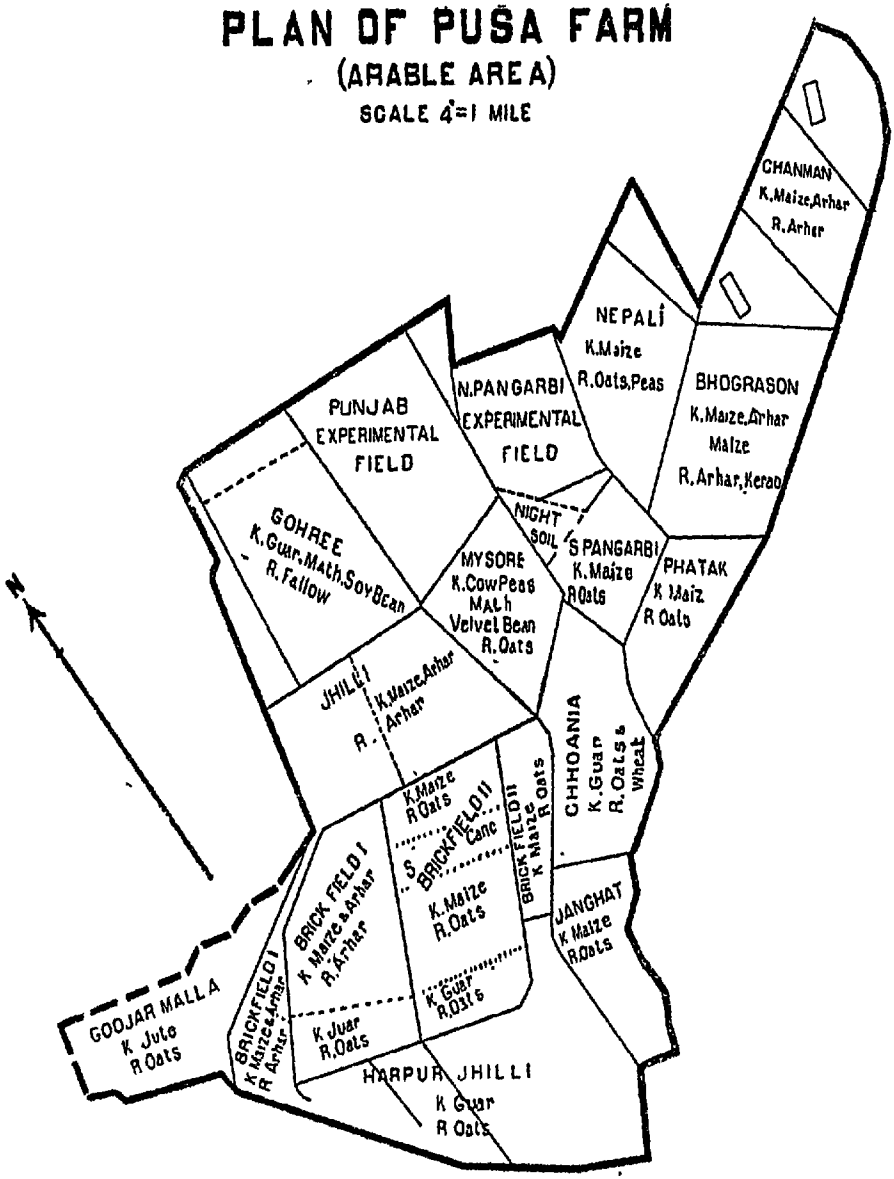
2nd year's rotation. No manure is given to the crops in the second year of the rotation. As a rule maize and *arhar*

* Exclusive of rents, rates and taxes and supervision charges.

PLAN OF PUSA FARM

(ARABLE AREA)

SCALE 4"=1 MILE



CATTLE FEEDING ON THE LEGUMINOUS CROP GUAR.

PLATE I.

are sown together so that the *arhar* remains as a *rabi* crop after the removal of the maize, thereby saving a considerable amount of cultivation at the busiest time of the year. The total area under this rotation was 140 acres out of which 119 acres were sown under maize and *arhar*.

The working costs for the year for all crops in this rotation were Rs. 22-10* per acre and the returns Rs. 96, giving a profit of Rs. 73-6.

The season was a fair one for maize corn and the best field Bhograson gave 14½ maunds, the average over all being nearly 9 maunds. The *arhar* crop, as mentioned above, finished badly owing to rain at the wrong time in February, 1920 when the crop was in full flower.

3rd year's rotation. In the 3rd year's rotation pulse crops are sown in *kharif* and fed off on the land. Four fields aggregating 132½ acres were sown under *guar* (*Cyamopsis psoralioides*), soybeans, *math* (*Phaseolus aconitifolius*), cowpeas and velvet beans. Out of this, 107 acres were fed off and 25 acres of *guar* in Chhoania field were cut green for stall-feeding. The latter area was subsequently sown with oats manured with 5 maunds of oil-cake per acre to make up for the removal of the crop.

The soiling began late (the 3rd of August), the sowing of the crop having been delayed by late rainfall. Two hundred and sixty-six head of cattle consumed an average of 2·6 acres of crop daily over a period of 40 days (Plate I).

Oats followed the pulse crop over 88 acres, 4 acres being left fallow for next year's sugarcane and hot weather maize and a small area reserved for wheat. The oats area received a dressing of one maund of superphosphate.

The best yield was 12½ maunds from Chhoania, the average being 11 maunds. Working cost was Rs. 32* per acre and return Rs. 53.

Sugarcane. The land for this crop is kept fallow during *rabi*, the moisture being conserved by repeated harrowings till the cane is planted in February without

* Exclusive of rents, rates and taxes and supervision charges.

irrigation. This year eight acres were under cane. A dressing of half a ton of oil-cake was applied per acre, half at planting time and the remainder on the first rainfall. The crop yielded an average of 472 maunds per acre and was sold to the factory at annas 11 per maund. The cost of production amounted to Rs. 116-9, and the return Rs 231-8 per acre. Twelve selected varieties were grown, *viz.*, thick canes: Sathi, Purple Mauritius, Kaludai Budan, D. 99 American and D. 1135; Thin canes: Java 36, Mungo, Yuba, Sarctha; Maneria, Kuswar and Reora. Twenty-nine varieties received from Dr. Barber, Government Sugar-cane Expert, were also grown for comparative tests on small areas. Out of these, Co 215, Co 201, Co 202, Co 204, Co 205, Co 206, Co 207, Co 208, Co 210, Co 213, Co 214, Java 213, Kuswar and Tobe Monjet did well and are this year being tried on a large scale. The thick canes are planted in rows 3 feet apart while the spacing of the rows for the thin varieties is $2\frac{1}{2}$ feet. This method of planting has been found the quickest and most economical in regard to labour. Furrows are opened by a ridging plough, followed by a sub-soiler to loosen the soil to a depth of about 9 inches. Sets are then laid horizontally in the furrows followed by a top-dressing of oil-cake. The sets are then covered by a special implement which is a combined *hanga* and roller.

Jute. 21·53 acres in Goojarmalla field were sown under jute for seed for the Fibre Expert to the Government of Bengal. The field is liable to flooding, but on account of the scanty monsoon rainfall the crop grew well and yielded 134 maunds of seed or an average of 6·25 maunds per acre.

Berseem. Berseem or Egyptian clover (*Trifolium alexandrinum*) was sown on an area of 8·46 acres commanded by irrigation from the river. This is a most promising fodder crop, providing fodder between seasons at a time when there is a scarcity of green food. An area of over 40 acres has now been levelled for the extension of this crop under irrigation. The fodder will be of great value to the milch stock.

Soiling. The practice of grazing fodder crops on the land has been found to be of great practical value. It now forms part of the rotation designed to determine if it is feasible to maintain the fertility of ordinary rain-watered land under intensive cropping. With irrigated land the matter is comparatively simple, but in rain-watered land the maintenance of fertility by simple practical methods is one of the most urgent of agricultural problems.

VI Permanent Experiments.

These were continued in the two fields specially laid out for the purpose.

(*a*) The permanent manurial and rotational experiments were continued. The results obtained up to the year 1918-19 were discussed by a sub-committee held at the time of the last Board of Agriculture.

The object of this series is to determine the specific effect on soil fertility of the more common organic and chemical manures applied alone and in various combinations to a two-year 4-course rotation.

Table I showing the treatment and results of outturns for the year 1919-20 is given below:—

Table I.

Plot No.	Treatment	"A" Series		"B" Series	
		Maize	Oats	Maize	Arhar
		lb.	lb.	lb.	lb.
1	No manure	603	489	382	864
2	Farmyard manure to supply 10 lb. nitrogen	829	581	471	924
3	Farmyard manure to supply 20 lb. nitrogen	1,036	614	772	1,271
4	Farmyard manure to supply 30 lb. nitrogen	1,251	733	779	827
5	Rape cake to supply 20 lb nitrogen	874	582	546	910
6	Sulphate of ammonia to supply 20 lb. nitrogen	493	357	244	1,002
7	Sulphate of potash to supply potash as in farmyard manure No. 3	417	358	261	830
8	Superphosphate to supply P_2O_5 as in farmyard manure No. 3	795	712	652	476
9	Sulphate of potash to supply potash as in farmyard manure No 3 Superphosphate to supply P_2O_5 as in farmyard manure No 3	790	617	850	476
10	Sulphate of ammonia to supply nitrogen as in farmyard manure No. 3 Sulphate of potash to supply potash as in farmyard manure No. 3 and superphosphate to supply P_2O_5 as in farmyard manure No. 3	790	622	1,004	618
11	Green manure and superphosphate to supply P_2O_5 as in farmyard manure No. 3	..	1,017	1,466	790

(*b*) The green-manuring experimental plots designed in collaboration with the Imperial Agricultural Bacteriologist were continued for the purpose of testing residues. The yields from the different plots are not included in this report as they show no departure from last season's results.

(*c*) The experiments in collaboration with the Imperial Mycologist regarding a method of dealing with die-back disease in chillies were continued.

(*d*) Six wheat varieties, Federation, Pusa 12, Pusa 4, Cawnpore 13, Maroo Booji, and Lyallpur 8A, which yielded well last year, were grown in a series of plots. The results owing to the deficiency of rainfall were in many cases very poor. The highest yield was 24 maunds 25 seers per acre from Federation, while the highest outturns of Pusa 4, Pusa 12 and Cawnpore 13 were 15 maunds, 21 maunds, and 18 maunds respectively.

(*e*) The experiments for comparing the comparative economic value of the common leguminous crops were continued. There are two series of plots in this experiment. One series is grown with *kharif* pulses to produce green fodder in the *kharif* and is followed by winter pulses for grain in the *rabi* season; the second series is for testing grain outturn of both *kharif* and *rabi* pulses.

The table below shows this year's results :—

TABLE II.

"A" Series.

Kharif pulses	Green fodder per acre in lb	How dealt with		Rabi pulses	Weight of seed per acre in lb.
		Fed to cattle	Left by cattle		
1. Soybeans	9,453	5/6	1/6	Val	933
2 Cowpeas	14,613	All	..	Lentils	597
3. Florida velvet beans	9,848	2/3	1/3	Purple peas	493
4. Florida Beggar weed	5,692	2/3	1/3	White peas	392
5. Math	14,710	All	..	Gram, small Kabuli	400
6 Urid (*Phaseolus radiatus*)	11,704	13/14	1/14	Gram, Cawnpore	770
7. Guar	9,527	6/7	1/7	Gram, local, Busa Bihar.	452
8. Val (*Dolichos lablab*)	4,033	2/3	1/3	Gram, yellow, of Gujarat District	448

VELVET BEANS FOR GREEN-MANURING.

PLATE II.

"B" Series.

Kharif pulses	Weight of seed per acre in lb.	Rabi pulses	Weight of seed per acre in lb.
1. Soybeans	1,135	Fallow as kharif crop was harvested late	..
2. Cowpeas	825	Ditto .	..
3. Florida velvet beans . . .	1,218	Ditto .	..
4. Florida Beggar weed . . .	127	Gram, Kabuli big .	353
5. Math	1,107	Fallow as kharif crop was harvested late	..
6. Urid	610	Ditto .	..
7. Guar	1,008	Ditto .	..
8. Val	502	Same crop standing in rabi .	..

Series A. Almost all the *kharif* pulses grown yielded well except *math*, *guar*, and velvet beans, which gave a less outturn of green fodder than last year, probably on account of the late arrival of the monsoon which delayed sowings. The cowpeas and *math* grown as green fodder were consumed by the farm stock.

In the case of the *rabi* pulses the yield of grain amounted to about one-half of last year's outturn on account of the late winter rains in February which fell when the crop was just in flower. The Yellow Gujarat and the local gram suffered most.

Series B. The grain yield of *kharif* pulses is high as compared with that of last year, but the late ripening of the crop prohibited the sowing of the succeeding *rabi* pulses.

(*f*) Experiments with Java and Sumatrana indigo conducted in collaboration with the Indigo Research Chemist and the Imperial Agricultural Bacteriologist, and the wilt disease experiments in collaboration with the Imperial Mycologist and the Fibre Expert to the Government of Bengal, were continued. These experiments will last over a period of years and the results will be dealt with from time to time by the Indigo Research Chemist and the Imperial Mycologist in their respective reports.

As in past years, crops were grown in the North Pangarbi field for the other Sections.

VII. Implements and Machinery.

Steam Ploughing Tackle. The set of tackle consisting of two single cylinder "K" class Fowler engines with steel wire rope and four furrow anti-balance gang plough, a disc harrow, a grubber, a zigzag harrow and a Crosskill roller, worked during the year for 126 days of 10 actual working hours each. The engines were also used for silage cutting and for driving an 8-inch centrifugal pump for irrigation both in the monsoon and cold weather seasons when there was no cultivation work to be done on the farm.

The cost of the set in 1913 was as follows :—

	Rs.
Two engines with steel cables	30,000
Plough	3,700
Disc harrow	3,625
Grubber	3,227
Zigzag harrow and roller	2,925
Total .	43,477

Details of output, fuel consumption and working costs, including all expenses except depreciation and interest on outlay, are given below.

TABLE III.

Output, consumption and cost of Steam Tackle during 1919-20.

(a) *Output.*

Year	Working days	SUMMARY OF WORK DONE								AVERAGE WORK IN ACRES PER DAY			
		PLOUGHING		DISC HARROWING		GRUBBING		ROLLING		TOTAL					
		Days	Acres	Days	Acres	Days	Acres	Days	Acres	Days	Acres	Ploughing	Disc harrowing	Grubbing	Rolling
1919-20	126	53	404·5	28	582	22	488	23	533	126	2007·5	7 6	20 7	22 1	23 1

(b) *Consumption of fuel, etc.*

Year	Days in work	COAL AND WOOD				ENGINE OIL		CYLINDER OIL		GREASE		WASTE	
		TOTAL		PER DAY									
		Mds.	Srs. Ch.	Mds.	Srs. Ch.	Mds.	Srs. Ch.	Mds.	Srs. Ch.	Mds	Srs. Ch.	Md.	Srs. Ch.
1919-20	126	4,032	10 0	32	0 0	11	37 0	3	22 8	0	28 0	1	12 17
		103	35 0	0	33 0								
		4,136	5 0	32	33 0								

(c) *Cost.*

Year	Days	ANALYSIS OF TOTAL COST						COST PER ACRE			
		Labour	Coal and Wood	Lubricating Oil	Miscellaneous	TOTAL	Per day	Ploughing	Disc harrowing	Grubbing	Rolling
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1919-20	126	1,200 0 5	1,622 8 11	633 3 7	1,195 15 3	4,632 2 2	36 14 9	4 13 8	1 12 6	1 10 8	1 9 6

TABLE IV.

Showing cost for working and maintaining the Steam Tackle in 1916-17, 1917-1918, 1918-19, and 1919-20.

Particulars	1916-17 No. of working days 151	1917-18 No. of working days 121.	1918-19 No. of working days 145·4	1919-20 No. of working days 126
	Cost	Cost	Cost	Cost
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Labour	1,233 0 0	910 1 6	933 10 9	1,200 6 5
Coal	1,788 0 0	1,424 9 0	1,655 13 9	1,022 8 11
Oil	300 0 0	315 0 0	481 14 9	633 3 7
Miscellaneous stores, etc., and renewals	713 0 0	3,418 13 9	1,064 4 1	1,195 15 3
TOTAL	4,034 0 0	6,098 8 3	4,135 11 4	4,052 2 2

TABLE V.

Showing the above costs divided into following operations per acre in the years 1916-17, 1917-18, 1918-19, and 1919-20.

Particulars	1916-17			1917-18			1918-19			1919-20		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Average per day	Total area cultivated in the year	Cost per acre	Average per day
	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres
Ploughing	287	4 6 2	7	170·5	9 3 2	7	373·5	3 11 4	7·3	404·5	4 13 8	7·6
Disc harrowing	498	2 0 9	18	821·5	3 0 3	20	605·5	1 11 9	16·4	582 0	1 12 6	20·7
Grubbing	1,030	1 7 4	25	616·0	4 5 7	26	668·0	1 6 0	20·7	188 0	1 10 8	22·1
Zigzag harrowing	41	0 14 9	27	11·0	2 2 6	..	..	..	..	..	..	..
Rolling	320	1 5 6	22	173·0	3 14 ·0	22	540·0	1 5 8	21·0	533·0	1 0 6	23·1
TOTAL	2,206	..	..	1,792	..	..	2,187	..	..	2,007·5	..	..

Fordson Tractor. After a trial and demonstration with implements used on the farm in May 1919 this machine was bought for Rs. 4,362 from Messrs. the Russa Engineering Works, Ltd., Calcutta, for further trials as regards fuel consumption and work. The tractor has now worked on the farm for fully a year in both *kharif* and *rabi* cultivation. The implements used include Ransome's double disc plough, a two 14-inch furrow Oliver plough No. 7, a Roderick Lean disc harrow, spring tooth harrows, a Cambridge roller and an Orwell spring tyne cultivator: also a Raja reaper for harvesting oats. The work of the Orwell cultivator and Roderick Lean disc harrow when used in conjunction with the tractor has been found excellent. The Raja reaper is too small for economic results and a self-binder would be more satisfactory. The tractor also did very good work in driving a Climax silage cutter for chaffing green maize and *juar*. Figures of output, consumption and cost excluding depreciation and interest are given below,

Table VI.

Output, consumption and cost of Fordson Tractor during 1919-20.

(a) *Output.*

Year	Working hours	Summary of work														Acreage per hour					
		Ploughing		Disc harrowing		Grubbing		Rolling		Drilling		Reaping		Total		Belt pulley work	Grand Total						
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Hours work	Acres	Ploughing	Disc harrowing	Grubbing	Rolling	Drilling	Reaping
1919-20	892·5	357·8	188·45	249	317·5	111·95	203·5	30·25	63	..	..	83	84	841	856·45	51·5	892·5	856·45	0·526	1·275	1·817	1·60	..	1·012

(b) *Consumption.*

Year	Working hours	Fuels	Engine oil		Gear oil		Grease	Waste
		Total gallons	Gallons per hour	Total gallons	Gallons per hour	Total gallons	lb	lb
1919-20	892·5	Kerosine . 1,387·5 Gasoline . 35·7 Total . 1,423·2	1·59	178·0	0·199	7	34	3·2

(c) *Cost.*

Year	Working hours	Analysis of total cost						Cost per acre					
		Labour	Fuel: Kerosine and Gasoline	Lubricants, etc.	Miscellaneous and renewals	Total	Per hour	Ploughing	Disc harrowing	Grubbing	Rolling	Drilling	Reaping
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1919-20	892·5	282 13 6	1,303 3 9	1,049 9 7	244 10 0	2,880 4 10	3 3 8	6 2 3	2 8 6	1 12 8	2 0 2	..	3 3 0

Austin Tractor. This machine was bought from Messrs. A. H. Wheeler & Co., Allahabad, for Rs. 3,268 and arrived on the farm in January 1920. It did equally good work to that of the Fordson with the same implements and was also used for breaking in land from jungle.

The following statement shows the output, consumption and cost during the period of three months' working.

Table VII.

Output, consumption and cost of Austin Tractor during three months of working.

(a) *Output.*

Year	Summary of work									Acreage per hour		
	Working hours	Ploughing		Disc harrowing		Reaping		Total		Ploughing	Disc harrowing	Reaping
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres			
1920	301·5	120 5	53 55	87	116 5	94·0	88·0	301·5	258 05	0·44	1·33	0·93

(b) *Consumption.*

Year	Working hours	Fuel	Engine oil		Gear oil		Grease	Waste
		Total gallons	Gallons per hour	Total gallons	Gallons per hour	Total gallons	lb.	lb.
1920	301·5	123 5 Kerosine 410 Gasoline 13·5	1·40	30	0·029	6	10	1·0

(c) *Cost.*

Year	Hours	Analysis of total cost						Cost per acre		
		Labour	Fuel, Kerosine and Gasoline	Lubricants, etc.	Miscellaneous and renewals	Total	Per hour	Ploughing	Disc harrowing	Reaping
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P
1920	301·5	84 5 0	390 10 11	205 8 0	3 8 0	684 0 8	2 4 4	5 2 7	1 11 4	2 7 0

The work of these two tractors have clearly shown the necessity for extensive trials of standard makes in India. It is possible that a number of modifications will have to be introduced before tractors can be recommended for ordinary zemindari conditions. The importance to India of the tractor movement is enormous. Plough cattle of powerful type are scarce and dear, and improved agriculture necessitates more power. It is useless to recommend an increased area of, say, sugarcane cultivation, unless means are provided for the extra power required for an increased depth of cultivation. A motor tractor equals in work 8—10 pairs of cattle. The subject is thus worthy of more attention than a few spasmodic demonstrations. Further, the introduction of tractors necessitates the provision of training schools for drivers and workshops for running repairs within easy reach.

The agricultural machinery trade in India is at present in an unsatisfactory state. Makers have no direct representatives in India but are represented by agents in the large towns. There are no stocks in the country and spare parts are increasingly difficult to get, and for these exhorbitant prices are sometimes charged. For example, a bill was presented for Rs. 1,200 for spares for a couple of reaping machines. Makers will undoubtedly have to contemplate the appointment of their own agents and the opening of depôts in upcountry districts.

It is obvious that the work of the Agricultural Departments in India must include both the testing of standard types of agricultural machinery and the adoption of such suitable modifications as are required by Indian and individual district conditions. This class of work is quite in its infancy and requires considerable capital and time. Agriculturists in India are further handicapped by the difficulty of getting into direct touch with manufacturers in England and America.

VIII. Pedigree Dairy Herd.

During the year under report this herd has progressed satisfactorily. As has been shown in former reports it is divided into two sections :—

(*a*) A pure bred Montgomery or Sanhiwal herd.

(*b*) A cross bred herd obtained by crossing the poorer Montgomery cows with Ayrshire bulls.

(*a*) **The Montgomery Herd.** The strict selection for milk yield is now giving results and the herd is slowly but steadily improving. It numbers over 244 head and it is hoped to reject this year all cows giving less than 3,500 lb. of milk in a lactation period of 10 months from calving.

It is satisfactory to record that a number of the new heifers have started with yields of over 3,500 lb. in their first lactation period of 10 months; as they are still in milk their names are not included in the list below.

The best results in the past year in the Montgomery section are :—

Table VIII.

Name of cow	Milk yield in lb. (10 months)	Sire	Dam	Dam's best yield in lb.
Joogni 142	6,457	Amritsari	Bowdhi 33	4,810
Syria 182	6,312	Amritsari	Godhi 99	5,954
Roomali 140	5,007	Amritsari	Banthi 37	4,228
Bhawani 214	4,451	Behari	Thombi 130	4,192
Chakli 203	4,317	Prayagi	Padmini 56	3,770
Anjani 210	4,247	Behari	Makhni 28	4,406
Ashrafi 211	4,217	Prayagi	Panji 30	4,065

The calves from the Montgomery heifers are now being weaned at calving time but great care and careful supervision is necessary. When the calf is weaned the cow takes the bull sooner and more regularly.

(*b*) **Cross Bred Herd.** The number of the cross bred herd is at present 91 head.

The best of the cows were:—

TABLE IX.

Name of cow	Milk yield in lb. (10 months)	Calving	Dam	Dam's best yield in lb.
Alibi No. 3	7,705	2nd	Sajni	3,021
Naomi No. 1	7,010	2nd	Thoombri	3,034
Daisy No. 5	6,481	2nd	Gujri	4,416
Kitty No. 10	5,089	1st	Wakdi	..
Patty No 8	5,600	1st	Rangoli	3,333
Peggy No. 9	5,805	1st	Phekni	3,510

The above results are very striking. The combined results at Pusa and at the various military dairies, in which records of hundreds of animals and over 10 years' experience are available, show that a cross of the well bred Ayrshire bull with an Indian cow will double the average milk yield of the Indian breed. The cross cow, too, comes in calf regularly and the calf can be weaned without difficulty.

The following table shows the yields of two cross cows, Jill, belonging to the Military Dairy, Bangalore, and Alibi at Pusa (Plate III).

TABLE X.

Lactation period	JILL (BANGALORE)		ALIBI (PUSA)	
	Number of days in milk	Yield in lb.	Number of days in milk	Yield in lb.
First	347	7,070	301	7,271
Second	306	8,031	301	7,989
Third	282	9,457	...	...
Fourth	303	11,329	...	...
Fifth	360	13,561	..	...

Fig. 1. Cross bred Cow "Jill" (Bangalore).

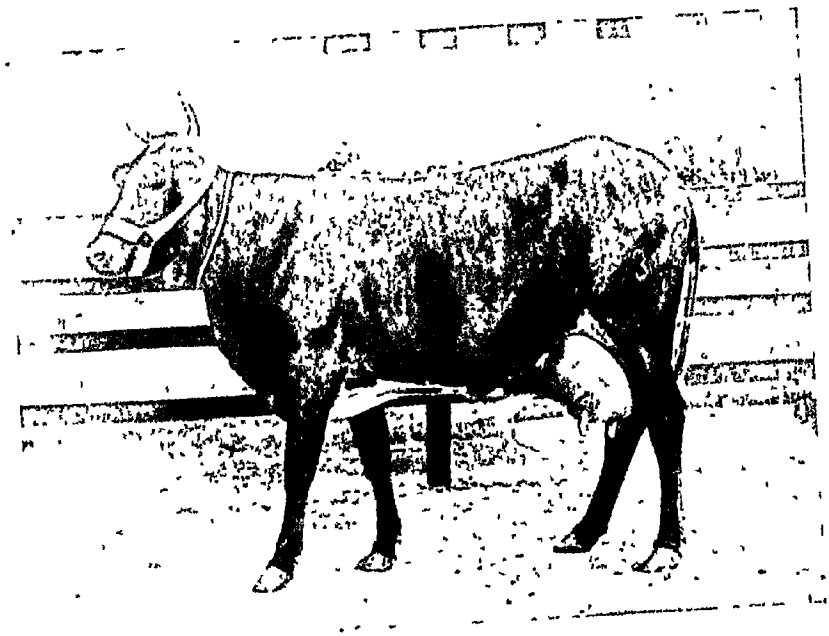


Fig. 2. Cross Ayrshire-Montgomery Cow "Alibi" (Pusa).

Total days from first calving of Jill to day prior to last calving, 1,944. Total yield, 50,360 lb. Daily average, 25·90 lb. Present yield from 21st March, 1918, to 31st October, 1918, is 9,800 lb. and still doing 30 lb. daily (October 1918). Per cent. butter fat, morning 4·44, evening 4·46.

From 1st April, 1920, to 30th July, 1920, Alibi has given 5,228 lb., giving an average daily yield of 43·2 lb. milk and is now giving 38 lb. milk per day.

It is obvious that cows of this type are enormously valuable. A cow giving 10,000 lb. milk in a year with the retail price of milk at 2 seers to the rupee is worth taking some care of. With reference to the comparative quality of the milk of the cross bred and Montgomery herds the average of a number of bulk samples showed about the same high content of butter fat for the two, *viz.*, 4·6 per cent.

Much criticism has been evoked on the subject of cross-breeding on the score of susceptibility to disease. This, however, is largely discounted by actual experience at the military dairies where rinderpest has been successfully combated by the method of simultaneous inoculation. Other cattle diseases are not nearly so dangerous. The main line of work in this connection is only at the beginning, *viz.*, the selection of a fixed type from among the cross breds. The ideal type of animal would combine disease resistance derived from the female side with the milk yield derived from the Ayrshire stock. To make headway with this work large numbers are essential and the addition of other stations is required.

IX. Sales.

A sale of surplus stock was held in March and was well attended. Thirty head realized nearly Rs. 7,000.

X. Staff.

The staff of the Agricultural Section, Pusa, though very short-handed, worked with great zeal during the year.

XI. Programme of work for 1920-21.

Major.

I. Co-ordination of work in the various Agricultural Departments by touring, etc.

II. Practical treatment of the Pusa Farm with special reference to suitable modern machinery and the economic results thereof.

III. Practical treatment of the Pedigree Dairy Herd and the fixing of a cross bred type of milk animal.

IV. Experiment work in collaboration with the various scientific Sections at Pusa as mentioned in the various sectional reports.

V. Rotation and fertility experiments on a field scale and the trial and acclimatization of new crops.

VI. Demonstrations and sales at Pusa.

Minor.

VII. General advisory work of an agricultural nature.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. SEN, M.A., PH.D.)

I. ADMINISTRATION.

Dr. W. H. Harrison was in charge of the Section till the 30th April when he proceeded on leave. After that I have been appointed to officiate in his place.

II. EDUCATION.

Mr. A. K. Mitra, B.Sc., stipendiary student of the Bihar and Orissa Government, completed his course of training in agricultural chemistry in March.

Mr. K. M. Banthia, B.Sc., stipendiary student from Ajmer-Merwara, underwent a training in general analytical methods for three months in this laboratory.

III. METEOROLOGY AND DRAIN-GAUGES.

The usual meteorological records were maintained. The crops and drainage waters from the drain-gauges were examined in the usual manner.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS.

A. The following samples were analysed and reported upon during the year :—

Soils	37
Manures	21
Feeding stuffs	22
Sugarcanes	60
Milk	8
Cotton seeds	40
Waters	26
Paddy husk ashes	2
Insecticide	1
Fungicides	2
Fire clay	1
Slaked lime	1

Stomach contents and livers of bulls . .	3
Miscellaneous	2
	229

Among the items of interest in this connection were samples of the commercial insecticides known as *Polvo* and *Katakilla*. *Polvo* is a powder which upon microscopic examination is shown to be of vegetable origin. The aqueous extract consisted largely of dextrinoid, resinoid matters with some small proportion of tannin. No specific alkaloids could be detected and the active principle appeared to be a sapotoxin. This was confirmed by its isolation and reactions, both chemical and biological. There appeared to be about 0·97 per cent. present in the sample. *Katakilla* seemed to be a mixture of *Polvo* with soap.

B. The following assistance was rendered to other Sections :—

Agricultural Section. Forty-four samples of sugarcane, 15 samples of manures and 4 samples of feeding stuffs were reported upon. Eight samples of milk of pure and cross-bred cows were also analysed.

Botanical Section. One sample of soil was analysed.

Entomological Section. One sample of sodium arsenate was examined.

Mycological Section. Two samples of fungicide were reported upon.

Indigo Research Section. Two samples of manures were analysed.

Cotton Specialist's Section. Forty samples of cotton seed were examined.

Sugar Bureau. Sixteen samples of sugarcane were analysed for the Secretary, Sugar Bureau

Imperial Bacteriological Laboratory. Two samples of feeding stuff and three specimens of the stomach contents and livers of hill bulls were examined for the Director and First Bacteriologist, Muktesar.

C. The examination of the soils of the experimental plots in the Punjab Field was completed. The results were submitted by Dr. Harrison in December 1919 to the Committee appointed by the Board of Agriculture to review the permanent manurial and rotation experiments at Pusa. These experiments, which were started in 1908, were designed to find out the specific effect on soil fertility of the more important organic and chemical manures, alone and in various combinations, in a 2-year 4-course rotation. It was also sought to determine how far soil fertility is affected by growing in rotation, leguminous crops (1) removed from the land, (2) returned to the land in the shape of green manures. The results obtained are noted below.

The effect of applications of organic manures. Bulky organic manures have a very appreciable effect in increasing the total crop, but whereas with cereals the proportion of grain is materially increased, the reverse is the case with *rahar* (*Cajanus indicus*). The residual effect of rape cake is inappreciable on the second crop, although its effect on the crop to which it is applied is very marked. Rape cake is therefore not as effective as farmyard manure when the application is only once in a full cropping season.

The effect of mineral manures. Of the manurial constituents nitrogen, potash and phosphoric acid when applied alone, the last is the only one which gives a distinctly positive reaction in Pusa soil, but the combination of all three gives the best results to the crop to which it is applied. In the case of cereals the use of phosphoric acid increases the proportion of grain, but in the case of *rahar* all manures increase the proportion of green matter.

The effect of pulse crops in a rotation. It was noted that the benefit due to the inclusion of legumes in the rotation is positive so far as the yield of grain is concerned, but the increases obtained are not of great magnitude and there is practically no change in the weight of straw produced. In the case of *rahar*, the addition of a shallow-rooted legume to the rotation resulted in slight decrease.

The effect of green manures. The very definite depletion of the yield of *rahar* under the influence of green-manuring—even when in conjunction with superphosphate—is very remarkable, but it receives some confirmation from the observation recorded above that the introduction of a second leguminous crop led to a slight reduction of the yield. It would almost seem that as if the use of green manures in conjunction with a leguminous crop of the type of *rahar* were deleterious. It is desirable that this point should be tested more rigorously.

Regarding the cereal crops the returns are very definite and distinctly demonstrate the great benefit derived from green manures, even in purely cereal rotations. The introduction of a legume into the rotation gives only a comparatively small increased benefit. The outstanding feature is, however, the value of a combination of green manure and superphosphate.

V. Methods of analysis.

As recommended by the Chemists' Conference held in February 1919, an investigation of the methods of analysis of nitrogen and phosphoric acid in manures and fertilizers has been undertaken at Pusa. Ease of manipulation together with the period of time involved in the estimations is being taken into consideration along with the accuracy of the results obtained. The results obtained so far are recorded below.

Nitrogen. Kjeldahl's original method for the estimation of nitrogen, and the various modifications which have been proposed by different workers are being closely studied in this laboratory. It has been found that in Kjeldahl's method where no potassium sulphate is used, as well as in Gunning method where no copper sulphate or mercuric oxide is used, the time taken for boiling is long. In the methods where both copper sulphate and mercuric oxide are used to hasten the decomposition, the chances of oxidation are generally better, but it is still possible to get good results in some of the methods where only one of these is used.

The results of experiments so far tried indicate that rapid and accurate determinations may be made by the Kjeldahl-Gunning-Arnold, by Dyer's modification of Kjeldahl method and by the Gunning method as followed at Pusa.

Phosphoric acid. In all the methods tried the results obtained were compared with the figures obtained by the standard magnesia method. Mention may be made here of the methods which appear to be promising amongst those studied so far. The Pemberton-Kilgore method which is the one in use in this laboratory gives accurate figures. In the case of substances like superphosphate, ashes, etc., the phosphoric acid can also be quickly and fairly accurately determined by titration with standard alkali. The process consists essentially in rendering the solution of phosphate just neutral to methyl orange, adding an excess of neutral calcium chloride and then titrating until alkaline to phenol-phthalein. The volumetric estimation of phosphoric acid by silver nitrate solution has its limitations but it is capable of yielding good results under certain conditions.

VI. The retention of soluble phosphates in calcareous and non-calcareous soils.

The investigations in regard to the retention of phosphoric acid in calcareous and non-calcareous soils referred to in previous years' reports have now reached a stage which has enabled Dr. Harrison to submit them for publication. Consequently, a brief summary of the whole investigation is now given.

It used at first to be maintained that the retention of soluble phosphoric acid of superphosphate by the soil is simply due to the precipitation of phosphate of lime and later on of phosphates of iron and alumina. The precipitated phosphate being exceedingly finely divided and being thoroughly disseminated in the soil was accounted to provide a continuous supply of phosphoric acid to the roots of the growing plant. Evidence, however, soon accumulated which tended to show that this simple explanation did not

entirely agree with observed facts. The retention of phosphoric acid by the soil is not satisfactorily explained on the purely chemical grounds and, in all probability, the physical phenomenon of adsorption is an important factor. Adsorption is an instantaneous process, and consequently under conditions which obviate any possibility of the formation of insoluble compounds, may be looked upon as the factor governing the range of distribution of the phosphoric acid through the soil and the availability of the retained phosphate. On the other hand, the introduction of a secondary factor such as the formation of insoluble calcium phosphates must considerably modify the result, but the magnitude of this modification must depend largely upon the rapidity of the reaction concerned. It is conceivable that if, for instance, the rate of reaction between monocalcic phosphate—the chief constituent of superphosphate—and calcium carbonate is very rapid the range of distribution through a soil will be limited. Conversely, given a very slow rate of reaction the distribution will be wider. Evidence on this point is conflicting and it is impossible to formulate with any degree of certainty the probable course of events in highly calcareous soils such as are found in Bihar and other portions of the Gangetic alluvium. It therefore appeared desirable to investigate the predominating factors governing the distribution of soluble phosphates through calcareous and non-calcareous soils.

A study of the reaction between calcium carbonate and monocalcic phosphate showed that this is an extremely rapid process resulting in the formation of the comparatively insoluble dicalcic phosphate. The latter in turn slowly reacts with further quantities of calcium carbonate forming tricalcic phosphate. During the course of reaction carbon dioxide gas is produced which by increasing the number of calcium ions in solution reduces very materially the quantity of phosphoric acid formed in solution. Consequently, with calcareous soils the importance of cultural conditions which will tend to keep the CO_2 con-

tent of the soil gases at a minimum and thus permit of a greater concentration of the phosphoric acid in the soil solution is apparent.

From what has been noted above about the action of calcium carbonate on a solution of monocalcic phosphate it would appear probable that this reaction must play a prominent part in calcareous soils in retaining those forms of soluble phosphates which are capable of reacting, but that, on the other hand, the effect of this chemical retention would be at a minimum in non-calcareoue soils, and in these circumstances adsorption may be the limiting factor. It is of the utmost importance to determine which of these modes of retention is the predominant factor in the two types of soil for not only must the "availability" of the retained phosphoric acid be very dissimilar in the two cases, but the distribution through the mass of soil must also be very different.

With this object in view parallel series of experiments were carried out with a Pusa soil, representing highly calcareous soils, and a soil from Kalianpur which is almost devoid of lime. These showed that the phosphoric acid of superphosphate is mainly retained through adsorption in non-calcareous soils, whereas the retention is mainly due to other causes in the case of calcareous soils. Support to the conclusion that the retention of superphosphate by calcareous soils is due to chemical combination is lent by the behaviour of solutions of di- and tri-sodium phosphates with the type soils. In these latter cases no chemical reaction could be demonstrated between calcium carbonate and the sodium phosphates and the retention here obeys the adsorption laws.

The rapidity of the reaction between superphosphate and calcium carbonate lends very strong support to the hypothesis that this reaction must be the determining factor in the retention of phosphoric acid under conditions in which it can occur. If this is correct, then it would appear that when superphosphate is applied to a calcareous soil comparatively insoluble calcium phosphates are im-

mediately formed *in situ*, thus limiting the distribution of the phosphoric acid through the soil and causing the superphosphate to have a very localized value. On the other hand, in non-calcareous soils it would appear probable that the range of action would be wider and the distribution more uniform throughout the mass of the soil. To test this, the distribution of the phosphoric acid of different phosphates by percolation through columns of the type soils was studied. The results showed that the distribution of superphosphate through a non calcareous soil is of an uniform type. The phosphoric acid penetrates to a considerable depth and consequently the effect of applications of superphosphate to such soils is widespread. On the other hand, the distribution of superphosphate in the case of calcareous soils is of a non-uniform type, the major portion of the phosphoric acid being held in the top layers of the soil. Consequently, the application of superphosphate to these soils has a very restricted effect and has therefore probably much less efficiency than equivalent amounts applied to soils of the opposite type. In proportion to the amount of superphosphate applied to the columns of soil, the soil solution of calcareous soils contains a much less concentration of phosphoric acid than in the case of non-calcareous soils. In the light of present knowledge this can only mean that the phosphoric acid retained is in a much more available form in the latter soils.

It has further been found that the presence of even 5 per cent. of calcium carbonate in a non-calcareous soil restricts the diffusion of the phosphoric acid of superphosphate. In fact, in such a case the phosphoric acid is practically completely retained in the top few inches. This shows that calcium carbonate is the determining agent.

On the other hand, it has been demonstrated that the distribution of the phosphoric acid of those soluble phosphates which are without action on calcium carbonate, through a column of soil is of an uniform type even in highly calcareous soils, and that the phosphoric acid penetrates to a considerable depth. It would, therefore, seem

very probable that such phosphates would be more efficacious than superphosphate in calcareous soils. This point is under investigation.

From the above it will be seen that the phosphate manuring of calcareous soils is obviously a very different problem to that of non-calcareous soils and requires special study.

VII. The windrowing of sugarcane.

An account of the work done at Peshawar on the windrowing of sugarcane has been submitted for publication. The investigation has further been continued in the laboratory during the past season. Samples of cane were cut into pieces and, after paraffining the cut ends, these were kept in desiccators. On examining these later on, it was found that the sucrose did not fall off but that, on the other hand, there was generally a slight increase of cane sugar. On wetting the canes which have been thus windrowed by desiccation there was a fall in sucrose content. It will be remembered that under field conditions at Peshawar there was noticed a similar increase of sucrose in the windrowed canes and that after a rainfall a deterioration of the canes set in. Canes are thus seen capable of being windrowed at Pusa where the temperature conditions are much higher than those obtaining at Peshawar. It appears that moisture is probably one of the important factors involved in these changes. In the laboratory, samples of canes were further examined under different conditions and the results obtained tend to show that the transformations of sucrose are caused by agencies which are present inside the cane and that enzymic activities are closely connected with these phenomena. This point is under further investigation.

VIII. The excretion of toxins from the roots of plants.

The water culture experiments detailed in the Pusa Memoir, Vol. II, No. 3, Botanical Series, "Note on a toxic excretion by the roots of plants" were supposed by the

author to support the view that the roots of crop plants excrete toxic substances. It may, however, be noted that these experiments were performed with ordinary well water and without any control tests, and that the method of experiment led to a considerable evaporation of water and a corresponding concentration of the dissolved salts. This being the case it was felt that the evidence was not conclusive and that a repetition of the experiments under more stringent conditions was desirable. With this object in view the same scheme of experiment was repeated with the exception that a synthetic nutrient solution was substituted for the well water, and "control tests" were introduced to check the results. The nutrient solution used was that of Knop.

A large number of wheat, *rahar* and gram seedlings were grown in this nutrient solution, and at the end of a certain period the solution was allowed to evaporate spontaneously until its volume was reduced to about one-eighth. The blanks were allowed to evaporate to one-third to one-fourth the original volume. Jars containing nutrient solution but bearing no seedlings were also treated in an identical manner, and constituted the "blanks." Seedlings were then introduced into these concentrated solutions, supposed to contain the excretions of plant roots, and the progress of crops grown in them was recorded. The results are noted below:—

Crops (of which progress is indicated)		Crops which had previously grown in the water				Distilled water
		Wheat	*Rahar*	Gram	Blank	
Gram	Period (in days) after which withering commenced	9	8	...	7	11
	Transpiration (in grams)	15·4	13·8	...	9 5	17·7
Rahar	Period (in days) after which withering commenced	15	21	21	17	39
	Transpiration (in grams)	15·0	22 9	17·5	21·5	32·3
Wheat	Period (in days) after which withering commenced	41	...	...	36	48
	Transpiration (in grams)	34·3	...	...	31·0	54·0
Total solids per 100 c.c. of water at the end of the experiment		0 269	0·154	0·226	0 382	nil

From the above table it is evident that, in general, the seedlings grown in "wheat," "gram," and "rahar" water throve better than in the "blank test" solution, and that seedlings grown in distilled water fared best. These observations led to the conclusion that the positive results obtained in the experiments recorded in the memoir were probably due to the concentration of the salts present in the well water and not to toxic excretions. This is confirmed by an examination of the figures for the "total solids" in the solutions. The concentration of "blank" water in which the seedlings grew the worst was the highest, whereas the best results were obtained in the distilled water. The results obtained from the other "waters" were intermediate in character and approximately proportionate to the concentration. In short, the present series of experiments point to the conclusion that increased concentration of any solution beyond a certain limit leads to a toxic effect by some or all of the component salts present in the solution. The strength of the solution in the original experiment recorded in the memoir works out approximately to 1·12 per cent., a concentration which no doubt will prove toxic to any plant. The presence of an alkaloid which the author inferred was the character of the excreted toxins could not be demonstrated in the present experiments, and consequently it is only possible to conclude that the effect which had been ascribed to toxic excretions, is in reality due to the high concentration of salts in the solution employed in the final stages of the experiment. An account of the present experiments which have been carried out by Mr. Mukerji has been submitted for publication in the "Agricultural Journal of India."

IX. Carbon dioxide in soil air.

Periodical determinations of carbon dioxide were made in the soil air of three plots in the Botanical Area. Of these the first plot was grassed down, the second was grassed down but was partially aerated by trenches, and

the third was kept surface-cultivated. The results are recorded below :—

Percentage of CO_2 in the soil gas from three different plots in the Botanical Area.

Date and the month when the soil gas was aspirated	Plot No 1 grassed down	Plot No. 2 grassed down but partially aerated with trenches	Plot No 3 surface cultivated	Rainfall in inches since the last analysis was made
13th, 14th and 17th January, 1919 .	0 444	0 312	0 269	...
20th and 21st February, 1919 . .	0 472	0 320	0 253	1·30
21st and 22nd March, 1919 . .	0 427	0 223	0·197	0 03
23rd and 24th April, 1919 . . .	0 454	0 262	0 203	1·36
16th and 17th May, 1919 . . .	0 271	0 257	0·133	0 57
17th and 18th June, 1919 . . .	0 341	0 274	0 249	1·27
17th and 18th July, 1919 . . .	1·540	1 090	0 304	10·08
25th and 26th August, 1919 . .	1·590	0 836	0 401	8 68
19th and 20th September, 1919 . .	1·910	0 931	0 450	7·38
21st and 22nd October, 1919 . .	1·297	0 602	0 305	2·23
14th and 15th November, 1919 . .	0 853	0 456	0 261	...
22nd and 23rd December, 1919 . .	0 398	0 327	0·219	0 02
19th and 20th January, 1920 . .	0 342	0 250	0 186	0 02
24th and 25th February, 1920 . .	0·382	0 342	0 238	1·70
19th and 20th March, 1920 . .	0 457	0 383	0 230	1·00
16th and 17th April, 1920 . . .	0 367	0 321	0 222	0·11
19th and 20th May, 1920 . . .	0 385	0 315	0 236	0 32
22nd and 23rd June, 1920 . . .	0 514	0 524	0 275	2·21

It will be seen that the percentage of carbon dioxide in the soil air is highest in the grassed plot and lowest in the cultivated plot, the air in the soil of the trenched plot being intermediate in composition. During the first six months of the year 1919 the carbon dioxide in the air of the grassed plot was between 0·5 to 0·3 per cent., that in the trenched

and cultivated plots being 0·3 to 0·2 per cent. and 0·3 to 0·1 per cent. respectively. There was a sudden rise in the carbon dioxide in the months July to September. In the grassed plot it rose to 1·5 to 2 per cent., in the trenched plot to 1·0 to 0·9 per cent., and in the cultivated plot to 0·4 to 0·5 per cent. This rise seems to be connected with the rainfall and with the movements of the soil water level. From the month of October there began to occur a fall in the carbon dioxide content, this being 1·3 to 0·4, 0·6 to 0·3 and 0·4 to 0·2 respectively in the three plots. These rises and falls were most pronounced in the grassed plot and less so in the trenched plot. The variations were of the least magnitude in the cultivated plot. The figures obtained during the year 1920 agree very closely with those of the previous year.

X. Tobacco experiments.

Determinations of the dry matters of this season's tobacco have confirmed the observations noted in the previous years that the yield of leaves in the case of "topped plants" is as good or even better than that in the case of "spiked" plants; as regards stems, the yield in case of the "topped" is much higher than in that of "spiked" plants.

XI. Paddy manurial experiments.

A series of experiments with local paddy were carried out to compare the effect of ammonium sulphate used as a manure alone and also in combination with green manures. It was found however that—so long as phosphate manures were simultaneously applied—an increasing dose of nitrogen gave increased yields up to 160 pounds nitrogen to the area. Beyond that point there is a falling off and with 320 pounds the yields are little better than with no nitrogen at all. The tendency was for small doses of nitrogen to increase the proportion of straw to that of grain, but with 80—160 lb. to the acre the increase in grain was greater than that of straw and, consequently, the most economical application would appear to be between 80—160 pounds of nitrogen.

Green manure used alone gave an increased total crop of 65 per cent. but, notwithstanding this, when used in conjunction with ammonium sulphate it had no appreciable effect.

The employment of ammonium sulphate as a manure resulted in a considerable increase in the percentage of nitrogen found in the grain, and the increase was approximately proportional to the amount of nitrogen added as manure. The actual variation was 1·15 per cent. of nitrogen in the grain from the no-manured pots to 2·39 per cent. nitrogen in that from the pots manured at the rate of 320 pounds nitrogen per acre. This very interesting point is being subjected to further investigation.

XII. Programme of work for 1920-21.

Major subjects.

1. Continuation of the investigations into the amount and nature of drainage water from fallow and cropped land.

2. The influence of manurial treatment of the soil on the composition of crops.

3. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

4. A laboratory study of the changes occurring in windrowed cane.

Minor subjects.

1. Checking the accuracy of certain methods of analysis in confirmation to the general scheme drawn up at the Conference of Agricultural Chemists.

2. A study of the conditions governing the formation of black alkali in soils irrigated by calcareous water.

XIII. Publications.

Harrison, W. H. . Report on Agricultural Chemistry, 1918-19, for the Board of Scientific Advice.

Harrison, W. H. . . The gases of swamp rice soils, Part VI. *Mem. Dept. of Agri. in India, Chem. Ser.*, Vol. V. No. 8. (*In the press.*)

Harrison, W. H. and Das, S. The retention of soluble phosphates in calcareous and non-calcareous soils. *Mem. Dept. of Agri. in India, Chem. Ser.*, Vol. V, No. 9. (*In the press.*)

Harrison, W. H. and Sanyal, P. B. The effect of windrowing on the composition of sugarcane. *Mem. Dept. of Agri. in India, Chem. Ser.*, Vol. V, No. 10. (*In the press.*)

Mukerji, J. N. . The excretion of toxis from the roots of plants. *Agri. Jour. of India*, Vol. XV, Pt. 5. (*In the press.*)

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(G. P. Hector, M.A., B.Sc.)

I. Introduction.

Mr. Howard held charge of the Section up till December, when he proceeded on 11 months' combined leave, accompanied by Mrs. Howard, Second Imperial Economic Botanist. I took over charge of the Section on 20th December and held charge for the remainder of the year.

In 1919 the hot-weather deputation of Mr. and Mrs. Howard to Quetta, for the purpose of developing the fruit industry of Baluchistan, terminated. The work has been handed over to the Local Administration.

The following are the main items of work which have been in progress.

II. Wheat.

In the Botanical Area, work on wheat during the past season has been confined to the growing of large areas of P 12, P 4 and P 6 as a nucleus of pure seed for distribution purposes, and to a trial of P 53, a new rust-resistant wheat produced by Mr. Howard by crossing on P 6, against P 12, to test its relative yielding capacity. The result of this test was as follows:—

No. of plot	Variety	Area	Actual outturn	Per acre outturn
			m. s. ch.	m. s. ch.
1	P 12	0 09	1 22 8	17 11 0
2	P 53	0 18	3 12 8	18 16 0
3	P 12	0 09	1 30 8	19 18 0

As a result of a severe rain-storm in January, P 53 lodged very badly, while P 12 did not suffer so much. All plots had black rust moderately.

In October 1919, seeds of the new Pusa wheats Nos. 46, 47, 48, 50, 51, 52, 53, 54 were sent to Mr. Burt, Deputy Director of Agriculture, Cawnpore, and have been under trial the past season at the Cawnpore, Kalianpur and Shahjahanpur farms.

Mr. Burt reports that as the areas were small and the experiment somewhat upset by two canal failures, the results are not sufficiently dependable to enable strict comparison with Pusa 12 to be made from the results of one year only. They indicate, however, taken in conjunction with the appearance of the standing crop, that several of the hybrids are very promising. Mr. Burt states that it seems likely all the wheats of the 50—54 series will be higher yielders than P 12. They possess stronger straw and hold their grain better.

Experiments were also conducted on P 12 to test the effect of varying irrigation and cultivation on yield and quality, but the results are not available for this report.

No large distribution of seed in bulk from outside sources has been made this season, but about 114 maunds of pure seed from the Botanical Area supply have been sent out to about 40 different applicants.

Spread of Pusa wheats. In the United Provinces, Mr. Burt reports that the systematic introduction of P 12 wheat in the Doab and Oudh portions of the Central Circle is being continued in co-operation with zemindars, Court of Wards estates and co-operative societies. Two District Boards have undertaken seed-storage schemes of considerable magnitude during the year, the main item in each case being P 12. In the Allahabad Division, a feature of the past year's work has been an increase in the number of cultivating zemindars growing considerable areas of this wheat. This is said to have materially assisted the seed-supply problem.

The introduction of P 4 in the canal-irrigated tracts of Bundelkhand is also being continued, and progress is only limited by the amount of seed which the staff can handle and the amount of pure seed available. A special simpli-

fied Taqavi procedure for the supply of P 4 seed in the Cawnpore Division has recently been approved by the Commissioner.

Mr. H. E. J. Peake, Solan Brewery, reports excellent progress from the Simla Hills, and the following Hill States are said to have introduced P 12 with success:—Keonthal State, Junga; Baghal State, Arki; Baghat State, Solor; Patiala State, Patiala; Sirmoor State, Nahan.

These States comprise the majority of the States in the Simla Hills, and with the exception of Patiala all the States speak most highly of this wheat. The acreage in Sirmoor is said to be roughly 600 acres, and the Chief Secretary of Sirmoor State reports that it is their intention to extend P 12 this coming year towards Dehra Dun. In two or three years there will probably be nothing but P 12 in the whole of Sirmoor. This result is largely due to the trouble and keen interest taken by Sardar Narain Singh, Chief Secretary. It is also reported that P 12 sold in the market for annas 10 more per maund than the local wheat.

Pusa wheats in Australia. With reference to the spread of Pusa wheats in Australia, the following occurs in the report of the judges of the Royal Jubilee Show held at Sydney, Australia, in March 1920:

"A sample of the Indian wheat, Pusa 4, exhibited by Mr. W. H. Scholtz, of Gilgandra, is worthy of mention. It yielded a percentage of excellent colour flour of 53 quarts to the sack strength, which was the highest water absorption of all the flours tested in the competition."

In the exhibit of strong wheats, Mr. Scholtz again stood first with an exhibit of Pusa 4, an achievement for the Indian wheat, and in the class for 5 strong flour varieties, Mr. Scholtz also stood first, two of his five being P 4 and P 107.

III. Indigo.

Full details of the work on indigo carried on by the Imperial Economic Botanist at Pusa are being published as a Memoir. During the past season, work has been confined to a continuation of observations on plants grown

in drained and undrained lysimeters, to the monthly examination of root-development, and the continuation of work on seed-selection.

Lysimeter experiments. According to the investigations of the Howards, indigo-wilt is nothing more than the effect of waterlogging and consequent lack of aeration. When there is heavy and continued rainfall, the water-level rises and the soil becomes waterlogged, the air supply to the growing roots and nodules of the plants is cut off, and the roots, consequently, cannot thrive. Hence the new roots and nodules begin to die off below and wilt appears above.

Evidence of this has been obtained by growing indigo plants in cemented lysimeters, provided with drainage openings. In cases where the openings were closed, all the plants in the lysimeter got wilt, even when growing in soil which was rich in phosphate, and those with free drainage all escaped, even when they were growing in a soil poor in phosphate. Observations on these plants growing in lysimeters are being continued for the second year, and the effect of drainage on the growth and the health of plant is still under observation. Field observations have afforded further evidence. The first sign of wilt in the Pusa Botanical Area appeared last year (1919) in the third week of July, *i.e.*, when the water-level was highest. When the water-level went down, aeration was regained to some extent and the plants began to improve. The water-level rose again in the first week of September, and again wilt appeared.

Root-development. Systematic monthly examination of root systems is being continued. It is found that the nodule and new-root formation begins in April, but up to the break of the rains their formation is very slow. Soon afterwards, they begin to grow quickly. When the water-level begins to rise, new roots and nodules are formed towards the surface, and the older, lateral roots begin to change their direction, turning upwards, till by the end of July their tips reach very near the surface of the soil, and almost all new roots and nodules are found in the upper three inches. Weak plants which cannot form new roots

in the upper soil quickly get wilt. In all cases of wilted plants, nodules have been found to be absent and new roots very few.

As a result of Mr. Howard's investigations, five types of root-development have been recorded—

(*a*) Early bush type, with all laterals at right angles and near the surface.

(*b*) Early vertical type, with all laterals near the surface but pointing down.

(*c*) Late bush type, with laterals at right angles, both near the surface and extending to some depth.

(*d*) A similar type to (*c*), but with laterals pointing downwards.

(*e*) No side branches, but tap root only.

Type (*a*) has been found much less subject to wilt than the others, and in the 1919 root examinations every case of wilt examined was found associated with deep-rooting.

Seed selection. As mentioned in previous reports, Java indigo is not uniform, but consists of a mass of heterozygotes differing widely in habit and character. This is due to the cross-pollination which takes place, owing to which selection by pure lines is not possible, as plants do not set seed under bag, and a system of mass-selection has therefore to be resorted to. Some types are deep-rooted with long tap roots, others shallow-rooted with surface roots. The habits above ground differ in similar ways, some being much more branched than others. There are also differences in the maturity of plants. The object of the selection is to obtain early, surface-rooting, freely-branching plants, which will give good yields of both seed and leaf. A considerable amount of selection work has already been done, and some types are already being tested on an estate scale. Further selection work was started in 1917-18 and is still in progress. In that year plants were selected for their free-branching habit and high yield of seed and leaf, together with other desirable qualities, such as earliness and surface-rooting. Seed of these selected plants was sown in August 1918 in separate lines. From these, 100 desirable

plants were chosen and arranged (in 1918-19), according to yield of seed, outturn of green plant at first and second cut, and condition of growth at the time of the second cut. Finally, the best were kept for sowing in August 1919, and the process is being repeated. In this way it is hoped to bring the crop back to a type which will thrive on the soil conditions of Bihar, giving good yields of both seed and leaf, and showing a high power of resistance to wilt.

IV. Linseed.

For some years a large collection of Indian linseeds has been grown at Pusa, and a lot of work done on the pollination, fertilization and classification of this crop, with the object of selecting superior types. During the past season, the main facts with reference to pollination and fertilization have been verified and the classification of previous years has been checked. This work has been carried out by Maulvi Abdur Rahman Khan, Second Assistant. Out of 233 original kinds, 129 have been selected and are still under observation. These 129 have been grouped into 38 classes, arranged according to colour and size of seed, colour of flower and shape of petal.

The seeds vary from yellow to brown and are grouped into three main classes, *viz.*, (*a*) yellow, (*b*) fawn, and (*c*) brown. Each of these seed-classes is again sub-divided into small-seeded, medium, and bold, while again within these groups there are blue and white-flowered types.

Much attention has been paid to the pollination of this crop. The details of this have already been described by the Howards (*Mem. Dept. of Agr. India, Bot. Series*, X, No. 5, pp. 208-211, Dec. 1919). The flowers open in the early morning, the actual time depending on temperature and humidity. The anthers burst longitudinally when the flower is half open, and at this time stand away from the stigmas. Later, when the flower is full open and dehiscence of the anthers complete, they close in on the stigma and self-pollination is effected. In many cases it has been observed that twisting of the styles occurs after the anthers begin to

burst, and that this twisting helps to move round the burst anthers and thus bring the pollen-covered surface of the anthers into contact with the stigma. Cross-fertilization is rare, but by no means unknown, and necessitates the bagging of seed in all exact work.

From the results of this work it appears the Central Indian types, having a deep root system, do not form good seed in Bihar. Local types, having a shallow root system, thrive well and form good seed, but the seed is small and inferior. To improve the seed of Bihar linseed, it will probably be necessary to produce a new race by crossing between Bihar and Central India types. A type possessing a root system like the Bihar varieties and seed qualities like the Central India types is desirable.

V. Tobacco, Grams, Hibiscus, etc.

Tobacco. Work on tobacco was restricted to the growing of Mrs. Howard's selected types, for the maintenance of pure seed. Of these, 51 were *Nicotiana tabacum* and 20 *Nicotiana rustica.*

Besides these, over an acre of the selected type, No. 28, was grown for seed multiplication, in order to obtain a large supply to meet the ever increasing demand for this type. From 1·2 acres, 15 maunds 5 seers of seed were obtained, sufficient to grow approximately 95,000 acres. In previous years it has been found impossible to grow sufficient seed of this type, owing to the difficulties of preventing cross-pollination, as other types were being grown in the vicinity. This year it was possible to allow the flowers to pollinate freely and set seed right throughout the season, so that a heavy seed crop was obtained.

During the period under review approximately 2 maunds of seed, sufficient for about 12,000 acres, of this type have been sent out, the largest quantities to the Indian Leaf Tobacco Development Company, Dalsing Serai, and to Burma.

Grams. During the period under review, the following types of selected Pusa grams were sown for observation and

multiplication of pure seed. The types and yields obtained are shown in the statement.

Area in acre	Gram type	Actual outturn	Per acre outturn	Remarks
		m. s.	m. s.	
0·26	17	2 36	11 6	
0 20	18	2 20	12 20	
0·31	18	2 30	9 14	
0 75	18	7 8	9 21	
0 37	23	3 28	10 24	
0 15	25	1 27	11 7	
0 20	6	0 8	0 31	Sown after indigo; germination very poor.

The season was a very unfavourable one, and the yields are low. Seeds of all these types are now being largely distributed, the quantity of seed available being quite insufficient to meet the demand. During the period, approximately 15 maunds of seed of types 6, 17, 18, 23, and 25 have been distributed.

Patwa (*Hibiscus cannabinus* L.). Eight selected types were grown in the season under review for maintaining pure seed. Type 3, a medium-early, tall, straight form, with little tendency to branch and of robust growth, has been found the most suitable for fibre production, and has been under distribution for some years. One acre was grown during the year for seed production, and yielded 3 maunds 20 seers, and some 10 seers of seed have been distributed.

Safflower. Twenty-four types (described in the *Mem., Botanical Series*, Vol. VII, No. 7) have again been grown during the year under report for observation and the maintenance of pure seed. Besides these, several new types, selected from seed procured locally and from Dacca, were also under study. These seem now fixed in character and have therefore been added to the already existing types. The Dacca types are spineless, and appear richer in dye

than the Bihar types, which are also all spinose, and for both reasons should be more valuable.

During the season, the crop of safflower was severely attacked by a fungus disease, identified by the Imperial Mycologist as *Rhizoctonia napi*. The first sign of disease appeared in the first week of January and the spread was continuous right through up to the seed-maturing stage. In the case of local Bihar types the attack was late and more pronounced, and consequently very little seed set in these types.

Yams. Eleven varieties of yams were received from the Straits Settlements last year and were sown with local yams for a comparative trial of yield and quality. The tubers received were very different in appearance from the common local yam, *suthni* (*Dioscorea fasiculata* Roxb.).

To test the quality, some tubers of each variety, after boiling, were given to local people, and two varieties. No. 288 and No. 290, were declared to be superior to the local *suthni*, and have again been sown for a further trial.

VI. Rice.

A considerable part of the time of the Officiating Imperial Economic Botanist has been spent in supervising work in Bengal on rice, in conjunction with the Acting Economic Botanist, Bengal. This work has, for its main object, the selection, and production by crossing, of high-yielding types, suitable for the various districts of the province, together with the study of the varietal and field characters of types and of their inheritance on crossing. In addition to the types already under distribution, the department now has two other high-yielding pure-line types of transplanted paddy, suitable for distribution in the eastern districts, while a new selection at Chinsurah promises to replace *Indrasail* (Dacca No. 1) and the local *Nagra*. The problem in West Bengal is briefly to reduce the duration of high-yielding types, such as *Indrasail*, without materially decreasing the yield. Owing to the prevalence of a short rainfall in the latter end of the season, the types selected for

East Bengal are rather late for the western districts, and a paddy which will stand a shorter rainfall is required. On good rainfall, *Indrasail* is a heavier yielder than *Nagra*, but *Nagra* flowers and ripens 7 to 10 days ahead of *Indrasail*, and in a season of short rainfall and in higher, drier situations *Nagra* is a safer paddy to grow. Crosses between the two are under observation, and it is hoped selections from these will be an improvement on either parent.

A large amount of work is being done on the inheritance of characters, particularly with reference to the combination of characters. These include such characters as earliness and lateness, size, shape, colour and consistency of grain, and various colour characters. Amongst coloured paddies, no fewer than 53 different colour combinations have been found with reference to the distribution of colour in leaf-sheath, nodes, glumes and stigma, and a number of reciprocal crosses between selected types of these are under observation.

Further work in progress includes a study of the transpiration of early and late types of *aus* and *aman* paddy, with a view to determine whether there are varietal differences in this respect, and ultimately of determining whether the transpiration ratio can be reduced by manuring or other cultural methods. Any method of economising water without reduction in yield would be of great value in Western Bengal.

VII. Jute.

In conjunction with the Fibre Expert, Bengal, a study of chlorosis in jute has been undertaken in the Botanical Area at Pusa. Chlorosis is prevalent in many varieties of jute throughout Bengal, particularly in the northern districts, and is responsible, where bad, for a reduction in yield of several maunds per acre. At first, it was supposed that a difference in root system was associated with chlorosis, healthy plants showing a strong development of surface roots, with little or no tap root, and chlorotic plants generally showing an absence of surface roots, and a tap

root which ultimately shows a tendency to turn upwards. Further observations, however, appear to show that this is an effect of the chlorosis, and not a cause. As the water-level rises and the soil becomes practically waterlogged to very near the surface in the rains, as in East Bengal, the healthy, well-nourished plants throw out more and more surface roots, till ultimately a bunch of surface roots is found close to the surface. The chlorotic plants, on the other hand, being enfeebled through their inability to synthesise carbohydrate, are unable to do this, and in consequence, in addition to being starved from above, are slowly asphyxiated from below. Finally, the tap root of such plants endeavours to turn upwards, away from the wet. A systematic examination of the roots is in progress with a view to determine this.

Cultures grown at Pusa seem to show that the chlorosis is undoubtedly hereditary, seedlings of a few days old showing signs of it. The main facts so far proved are :—

1. *Chlorotic* plants never breed pure, but always throw greens.
2. *Green* plants may (as opposed to *chlorotic*) breed practically pure, but generally throw chlorotics.
3. The percentage of chlorotics (whatever the parent is, green or chlorotic) is not constant. In the variety *Kakya Bombai*, in 1919, out of 42 plots, the percentage varied from 11 to 30, with an average of 21·5.
4. By constantly selecting chlorotics and breeding from these, a race of practically pure chlorotics can be produced, and by constantly selecting greens, a race of practically pure greens can be produced, but no absolutely pure race of either has yet been obtained. In chlorotic plots a few greens always appear, and in green plots a few chlorotics.

The facts tend to show that it is possibly a case of maternal inheritance, the disease being passed on through the cytoplasm of the egg-cell. This cannot be definitely

proved till the results of crosses between chlorotic and green plants are available. A number of crosses made in Dacca last season were unfortunately destroyed in the cyclone, but the work is being repeated this season both in Dacca and Pusa.

A form of chlorosis very similar to that in jute has been found to be prevalent in *rahar* (*Cajanus indicus*) in Pusa, and selections have been made for the purpose of further study. It is proposed to make further search amongst other crops. Chlorotic plants have been frequently noted in the species of *Phaseolus* cultivated in East Bengal, and it is possibly a fairly frequent phenomenon.

VIII. Programme and Publications.

Programme for 1920-21. Investigations will be continued on the following crops on the lines of previous years—wheat, indigo, tobacco, fibres, grams, oilseeds, fodder crops and fruit.

Publications. The following papers were published or written during the year :—

1. Report for 1918-19 on Economic Botany for the Board of Scientific Advice, by A. Howard.
2. Studies in the Pollination of Indian Crops, I, by A. Howard, G. L. C. Howard, and Abdur Rahman Khan. *Botanical Memoir*, Vol. X, No. 5, December 1919.
3. The "Spike" Disease of Peach Trees: An example of unbalanced Sap-circulation, by A. Howard. *The Indian Forester*, Vol. XLV, No. 12, December 1919.
4. Some Labour-saving Devices in Plant-breeding, by A. Howard and G. L. C. Howard. *Agri. Jour. India*, Vol. XV, No. 1.
5. The Improvement of Fruit Packing in India, by A. Howard and G. L. C. Howard. *Agri. Jour. India*, Vol. XV, No. 1.
6. Some Aspects of the Indigo Industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo, by A. Howard and G. L. C. Howard, assisted by Abdur Rahman Khan and Chaudhari Ram Dhan Singh. *Botanical Memoir*, Vol. XI, No. 1. (*In the press.*)

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. BUTLER, D.Sc., M.B., F.L.S.)

I. CHARGE AND ESTABLISHMENT.

I held charge of the Section throughout the year, except for the period from 1st May to 17th June, 1920, when I was appointed sub. *pro-tempore* Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa. Mr. G. P. Hector, Officiating Imperial Economic Botanist, held charge during this period. The work as Joint Director was unusually heavy last year owing to the development of proposals for the expansion of the Agricultural Research Institute and the revision of pay of establishments due to changed conditions after the war, and left little time for mycological work. The Section further suffered by the absence of Mr. Dastur, Supernumerary Mycologist, on deputation to England from the end of August 1919, and of Dr. Shaw, Second Imperial Mycologist, on leave from 5th February, 1920.

Towards the end of the year I was appointed Director of the Imperial Bureau of Mycology in London, and leave shortly to take up this post, Mr. W. McRae, Government Mycologist, Madras, succeeding me as Imperial Mycologist.

Mr. M. Mitra, M.Sc., who entered the Section as a private student last year, was appointed First Assistant from 1st April, 1920.

II. TRAINING.

In addition to Mr. M. Mitra, mentioned above, Pandit S. D. Joshi, a private student from the United Provinces, continued his post-graduate course and was granted a stipend by his Local Government. Mr. T. Padmanabha Pillai, Mycologist, Travancore State, worked at laboratory methods during a period of one month from 5th February, 1920.

III. Diseases of Plants.

(1) Black band disease of jute. The research work on this disease was continued by Dr. Shaw. In Bihar, in 1919, the state of the jute crop was similar to that in 1918. A considerable portion of the seed-crop had, however, been sown as late as June and this was invariably clean and healthy. This confirms the observations made last year from the infection of the crop all over Bihar that the late sown crop is relatively immune. In the more early sown areas the crop was only slightly diseased and not to an extent which would seriously diminish the yield. The condition of the crop on the Dacca Farm by no means agreed with that in the previous season. Both the green and the red-stemmed varieties of *Corchorus olitorius* were attacked. The incidence of the disease was not heavy and varied considerably in different fields on the farm. The greatest damage seen in any one area was probably about ten per cent. The red-stemmed *C. capsularis* was also attacked. These observations are quite sufficient to show that neither the red-stemmed varieties of *C. capsularis* nor of *C. olitorius* were resistant to the disease. At Chinsurah Farm where the jute consisted of the same red and green varieties as at Dacca, the crop was very fine, averaging about 14 feet in height, and there was not a single case of black band. At Rangpur the crops of both *C. olitorius* and *C. capsularis* were infected. The disease, however, only reached an appreciable degree when the plants were of a certain size.

Infection experiments carried out both on plants in pots and on plants in the field showed that though red varieties of *C. capsularis* and *C. olitorius* are by no means immune yet under the conditions of the experiments they seem less susceptible. A large number of experiments carried out on green *C. capsularis* showed that the number of successful infections depended on the humidity of the air at the time of experiment and the exact determination of the conditions is a point for further investigation.

The field experiments carried out in 1918 with the object of throwing light on the conditions affecting the spread of the disease were repeated.

1. Two plots (A and C) were sown with seed of green-stemmed jute about 5th March, the former with treated and the latter with untreated seed. The land had carried jute which was slightly drained the previous season but had not been under jute previously for 25 years. *D. Corchori* was practically absent in both plots; only some 3 or 4 cases could be seen.
2. In similar plots (B and D) a crop of *C. olitorius* and of red-stemmed *C. capsularis* also remained free from the disease.
3. Two plots (E and F), each about $\frac{1}{4}$ acre, situated in a portion of the field in which jute had some disease the previous year and was particularly bad the year before, were sown with seed of green-stemmed jute. The seed was steeped in a solution of copper sulphate. Germination was scanty and both plots were resown on 4th July after the commencement of the rains, and gave a crop of typical late sown jute, short in height and thin in stem. In both plots the number of stems infected with *D. Corchori* was negligible, only about 12 cases could be found when the crop was cut early in November.
4. Of two plots (H and K) about $\frac{1}{3}$ of each plot was sown on 5th March with a red-stemmed and the remainder with a green-stemmed variety of *C. capsularis*. These plots were situated in the land which had carried the diseased jute in 1918. Both the varieties of seed sown had been steeped in 2 per cent. copper sulphate. Plot H carried a very scanty crop and had 31 cases of *D. Corchori* among the green-stemmed and only 6 cases in the red-stemmed variety. In plot K the crop was much thicker, both germination and growth having been better than in plot H. In plot K there were 190 cases of *D. Corchori* among the green-stemmed and 34 cases in the red-stemmed variety.

5. Plots (M and N), each about ¼ acre, were selected in good land which had never carried jute before. Plot M was sown on 5th March with seed of green-stemmed variety which had been treated by steeping in copper sulphate solution, and plot N was sown on the same date with seed which had not been so treated. Both plots gave an excellent crop of jute, 9—11 feet in height. In both plots nearly the same number of stems were diseased owing to *D. Corchori*—76 stems in Plot M and 56 in Plot N.

As a result of these field experiments, particularly from a consideration of the last two plots, it cannot be said that seed steeping in copper sulphate has any influence on the severity of the disease, and, therefore, as mentioned above, the dissemination of the disease cannot take place to any appreciable extent through spores of *D. Corchori* mingled with the jute seed. The percentage of disease was also not to any extent greater in those plots which had been under jute for two or more successive seasons. Steeping the seed may then be discontinued.

An account of the work done on this disease during the last three years is now in the press as a Memoir.

(2) Fruit work in Kumaon. The season's practical work for 1919 was completed in July. The chief diseases dealt with were apple mildew (*Podosphæra*), which most nearly approaches epidemic conditions in these orchards, branch blister and apple cracking due to *Coniothecium chomatosporum*, fly speck and sooty blotch (*Leptothyrium Pomi*), and peach leaf curl (*Exoascus deformans*).

The apple mildew spraying series included a test of home-made lime sulphur, Berger's lime sulphur, and Burgundy mixture, lead arsenate being added in each case. The trees stood even the "winter" strength of lime sulphur successfully and the experiments showed that an application of this fungicide made at the proper time will largely control the disease. Berger's mixture proved very satisfactory and simple to use. Further experiments with iron sulphide

are, however, required before deciding on lime sulphur as the routine treatment.

For the *Coniothyrium* disease the same sprays were used. In general the superiority of the fruit on the sprayed rows was very marked. The home-made lime sulphur and Berger's mixture both gave good results and did no damage to the trees. Burgundy, however, caused so much damage to fruit and leaves as to be largely a failure. This bears out recent work in English orchards with this mixture.

There was little *Leptothyrium* present but the trees sprayed with lime sulphur and Burgundy had certainly less than the others. Burgundy injury was again marked. Peach leaf curl was entirely controlled by all three sprays.

The variation between different varieties in susceptibility to disease as well as in resistance to Burgundy injury is so marked that it is useless to expect comparative results unless the tests are made on the one variety. Northern Spy is so susceptible to mildew that it is being discarded on at least one estate. King of the Pippin was immune to *Coniothecium*. Burgundy injury was very bad on Cox Orange Pippin and the leaves were scorched on Esopus Spitz, while King of the Pippin was quite free from it.

I visited Ramgarh in October with Dr. Shaw and discussed future work on the spot. The proprietors of the Allen Orchard are kindly placing at our disposal a small building for mycological work. Owing to Dr. Shaw's absence no new experiments have been carried out in the 1920 season.

(3) Cereal diseases. It has long been apparent to mycologists in India that there is a large group of parasites belonging to *Fusarium*, *Helminthosporium* and allied genera which attack cereals throughout the country. Some of these, such as the stripe disease of barley, are well known in other countries, others appear to be peculiar to India or at least have not been previously described. Mr. M. Mitra took up the study of the species allied to *Helminthosporium* and has made considerable progress in this enquiry, which is likely to extend over several years.

Species of *Helminthosporium* were found commonly attacking maize, *jowar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoideum*), rice, wheat, oats, barley, and sugarcane. In every case the chief attack is on the leaves, and excepting the stripe disease of barley the symptoms are on the whole very similar.

The parasite concerned was isolated from each of the above hosts and grown in pure culture for comparative study. Wheat was found to have a considerable range of forms on it in different parts of India. They appear to be related to *H. teres* Sacc. On rice the common species appears to be *H. Oryzæ* Hori, previously described from Japan. *H. turcicum* Pass. occurs on maize and *jowar* but freely grows also on wheat, oats, barley, and sugarcane. It does not attack *bajra* and only rarely rice. The species on sugarcane and rice attack all the hosts on which they have been tried whereas the wheat and barley species give reciprocal successful results. Further work on these lines is being done.

An allied genus, *Acrothecium*, is parasitic on several of the *Gramineæ* and one species attacks *bajra* at Pusa somewhat severely. It is a new species, which has been named *Acrothecium Penniseti*. The attack is on leaves, leaf-sheaths and ears, the leaf-form being the commonest but the ear attack probably doing most damage. The spikelets are attacked in clusters and the grain aborted. The attack is, as with so many other fungus diseases at Pusa, closely dependent on the atmospheric humidity.

The parasite has been isolated and studied in artificial culture by Mr. Mitra who has written a detailed account of it, now in the press as a Memoir. It is a vigorous parasite, with general points of similarity to other parasites of allied genera. It can attack maize ears but not the leaves; *jowar* is immune.

A second species, *Acrothecium lunatum* Wakker, is common at Pusa on maize and *jowar*, as well as on several wild grasses. It appears to do a good deal of injury to the male inflorescence of the former, where it is sometimes

associated with *Acrothecium falcatum* Tehon, but it is only a weak parasite on *jowar*. It is capable of attacking young leaves of *bajra* to some extent. Another form is found on rice. All these are being studied in pure culture.

Last season we received a number of reports and specimens of disease in wheat with the general symptoms of the foot rot disease which has attracted so much attention in the United States in recent years. As in that country a group of fungi seems to be responsible. The three fungi so far found in India are *Rhizoctonia destruens*, a *Pythium* of the *gracile* group, and a *Fusarium*. Of these the last is the most destructive, the other two being responsible in a limited number of cases only. All three fungi were isolated in pure culture by Mr. L. S. Subramaniam and successful inoculations were obtained with them on wheat grown at Pusa.

(4) Pythium disease of ginger and other crops. A Memoir describing fully this disease was published by Mr. L. S. Subramaniam during the year. As the work was summarized in last year's report it need not be further referred to here.

(5) Potato storage rots. Considerable attention has been given to the study of the means of preventing rotting of potato tubers during the hot weather and rains. Complaints of heavy losses from this cause leading to an excessive price of "seed" tubers at planting time, have become very frequent of late. A series of experiments was conducted at Sialkot in collaboration with the Punjab Department of Agriculture.

In storing potato tubers a two-storeyed well-ventilated house was selected and fumigated with sulphur vapour. Two sorts of tubers were selected: (*a*) from fields where potatoes were grown as ordinary routine crop, (*b*) from fields where potatoes were grown for the first time. The selected potato tubers were then put into sterile gunny sacks and fumigated with petrol vapour for 24 hours. Some of these fumigated potatoes were

stored (1) in dry sand, (2) in sacks loosely packed, and (3) on racks made of wooden battens. The rest of the fumigated potatoes were treated in corrosive sublimate solution (1 in 2,000) for 1 hour and afterwards taken out and dried and were stored exactly in the above manner. The experiment lasted during May and June 1919. The year being exceptionally trying on account of the excessive heat, potatoes started rotting very soon and in every case the bulk of the potatoes became rotten.

These results bear out the conclusion previously come to that the rot is primarily a result of excessive temperature and that it will be difficult, if not impossible, to check unless some form of cool storage can be devised. The natural suggestion is storage in the hills (at present a large proportion of the plains crop is from hill-grown seed and it should be possible to develop this by improving transport facilities and cheapening freight) but the alternatural suggestion is storage in the hills (at present a Further work is required so as to get a more exact knowledge of the temperature limits at which storage may be expected to pay.

(6) Root rot of cotton. The writer visited Lyallpur in October 1919, to make a further attempt at diagnosing the cause of this disease. Previous efforts at Lyallpur and Hansi had been unsuccessful, the causes then assigned not standing the test of more exact observations and experiments. The conclusion arrived at on this last visit is that the disease is a non-parasitic one which is associated with some unknown soil condition. Further work will probably have to be taken from another side than the mycological. The disease occurs sporadically through most of Northern and Western India.

IV. Systematic work.

A good deal of progress was made in the preparation of a fungus flora of India, so far as the materials at present exist. The total number of recorded species is probably under 2,000 which is certainly not one-fourth of those that

associated with *Acrothecium falcatum* Tehon, but it is only a weak parasite on *jowar*. It is capable of attacking young leaves of *bajra* to some extent. Another form is found on rice. All these are being studied in pure culture.

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exist. It is hoped to continue this work as opportunity permits.

An interesting paper has recently been published in the Philippines which gives evidence to support the view that the bud rot of coconuts is caused by the same fungus that causes canker of rubber and cacao and is usually known as *Phytophthora Faberi* Maublanc. If this is correct and the cause of bud rot in the Philippines is the same as in India this fungus will rank as one of the most destructive known. Its Indian name, *Phytophthora palmivora*, has priority over that given above.

V. Programme of work for 1920-21.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation:—

(*a*) Black band of jute.
(*b*) Chilli diseases.
(*c*) *Fusarium* wilts, especially in relation to soil and manurial conditions.
(*d*) Sclerotial diseases of jute, sugarcane, paddy, and Rangoon bean.
(*e*) Orchard diseases.

Minor investigations will include the study of some fruit anthracnose, *Orobanche* on tobacco, root rot of cotton, sugarcane smut, *sâl* root rot, and *Pythium* disease of papaya, ginger and tobacco.

(2) *Systematic work.* It is hoped to resume this with the facilities provided by the proposed Imperial Bureau of Mycology in London. Steps will be taken to supply the Bureau with representative collections from India. The preparation of a list of Indian fungi will be continued.

(3) *Training.* This will be continued on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance will be given to Provincial Departments of Agriculture and other Departments and to the general public.

VI. Publications.

Butler, E. J. . . Report on Mycology, 1918-19, for the Board of Scientific Advice.

Subramaniam, L. S. . A *Pythium* Disease of Ginger, Tobacco and Papaya. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. X, No. 4, December 1919.

Shaw, F. J. F. . Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori* Syd. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 2. (*In the press.*)

Mitra, M. . . Morphology and Parasitism of *Acrothecium Penniseti* nov. spec. (A New Disease of *Pennisetum typhoideum* Rich.) *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 3. (*In the press.*)

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June, 1920. The services of Mr. M. Afzal Husain, M.Sc., Supernumerary Entomologist, were transferred to the Punjab Department of Agriculture from 16th September, 1919, since which date the post of Supernumerary Entomologist has remained vacant. Mr. G. R. Dutt, B.A., was appointed Personal Assistant to the Imperial Entomologist from 1st May, 1920.

II. Training.

Mr. G. D. Austin, a student deputed by the Ceylon Department of Agriculture, was received for training on 1st June, 1919, and completed the ordinary course on 31st March, 1920, but has been given an extension up to September 1920.

Three students completed a short course in sericulture and two were under instruction at the end of the year. Two students sent from the Agricultural College at Sabour were also given instruction not amounting to a regular course.

III. Insect Pests.

Cotton. The species of *Acrocercops* referred to and figured in last year's Report has since been named by Mr. E. Meyrick as *A. zygonoma*, n. sp.

The question of determining the relative immunity of varieties of cotton was continued. Germination of the plants was very satisfactory but at the close of the year the experimental cotton plants suffered from drought and heat,

the maximum shade temperature reaching as high as 112·3°F. The ground soon lost moisture and as a result the plants did not boll well; indeed, in the case of some varieties of cotton, there were no bolls at all to continue the countings. *Sylepta derogata*, together with *Phenacoccus hirsutus* and *Ph. corymbatus*, appeared and did considerable damage to certain varieties of cotton. During the year *Hibiscus abelmoschus* continued to be a better trap-crop for Cotton Bollworms (*Earias*) than either *bhindi* (*Hibiscus esculentus*) or hollyhock, and as in previous years a larger number of bollworms and of *Microbracon lefroyi* were found in the pods of *H. abelmoschus*. A survey of alternative foodplants of bollworms was made and is being continued. *Microbracon lefroyi* continued to be the most prominent parasite of *Earias*.

Rice. Work on the borer pests of rice has been continued in the neighbourhood of Pusa and confirmed the conclusion arrived at in last year's Report that on the average *in the Pusa district* these borers cause a relatively small amount of damage, amounting to about 4 per cent. In order to get an idea of their activities in some of the other rice-growing districts in Bengal and Bihar, the rice-stubbles of the following places were examined in December 1919.

At Chinsurah, stubbles examined in and around the Farm showed about 13·5 per cent. damage by borers. The actual damage to the crop (for reasons explained in the preliminary paper on Borers) would be less than this. In about 800 stubbles examined the following insects (larva, pupa or empty pupa-case) were obtained :—

Schœnobius bipunctifer	5
Chilo simplex	1
Chilo oryzæ	1

At Midnapur, stubbles collected from the neighbourhood of the town showed about 5·4 per cent. damage by borers. From about 500 stubbles examined the following insects were obtained :—

Schœnobius bipunctifer	7
Chilo simplex	1

At Bankura, stubbles collected from the neighbourhood of the town as well as from the villages in the interior showed about 22 per cent. infestation by borers. In about 1,000 stubbles examined the following were found :—

Schœnobius bipunctifer	12
Chilo simplex	9

At Cuttack, stubbles collected from all over the Farm exhibited only 9 per cent. damage by borers. From about 900 stubbles the following were obtained :—

Schœnobius bipunctifer	3
Chilo simplex	3
Chilo oryzæ	5
Sesamia inferens	3

From many of the experimental plots on the Cuttack Farm the crop was not yet harvested and some of these plots (each 1/5th acre in area) showed an unusually high proportion of dry ears. For instance, in two plots, one of a variety known as *khura* and the other of *kukrajota*, the number of dry ears was as high as 20 per cent., whilst in neighbouring plots under the same varieties of paddy the damage was much less than half that in the two plots mentioned. From the *khura* plot referred to 100 affected plants were pulled out from all over it and of these 40 were not damaged by insects whilst the remaining 60 exhibited damage by borers, of which the following were found :—

Schœnobius bipunctifer	30
Chilo simplex	8
Sesamia inferens	2

Out of 100 affected plants similarly picked from the *kukrajota* plot, no less than 92 were found damaged by borers and the following borer larvæ were obtained from them, *viz.*:—

Schœnobius bipunctifer	30
Chilo simplex	38
Chilo oryzæ	2
Sesamia inferens	1

There was no apparent reason why so many insects should have been concentrated in individual plots in this manner. The larvæ of *Chilo simplex* were observed to occur plentifully in the stems of *Coix lachryma-jobi* var. *aquatica*, which was growing as a weed all over the Farm and amongst the rice-plots, but all these experimental plots of rice-plants seemed equally subject to their influence. The concentration of the borers in individual plots seems therefore difficult to explain unless it was due to lateness of the crop.

From the above facts it would appear that *Schœnobius bipunctifer* and *Chilo simplex*, the former especially, are more important than other borers in rice. The combined effects of damage by borers in rice, however, in Bihar and possibly in Bengal, does not seem to amount to very serious proportions although even a loss of 4 or 5 per cent. in the case of an extensive crop such as rice becomes a noteworthy sum when expressed in money value. In the case of other parts of India, notably Madras and Bombay, the damage to rice by borers appears to be much greater, so far as we have definite figures, but it would be very desirable to obtain more exact information. Even taking the annual loss by borers at only 5 per cent. for the whole of India we find the annual loss to be approximately four thousand seven hundred millions of pounds of rice annually, and this figure may probably be at least doubled when we consider the total losses due to all rice-pests in India.

The Halticine Chrysomelid beetle (C. S. 2043), mentioned in last year's report, has been observed to occur largely on *china* (*Panicum miliaceum*). It is incapable of injuring plants standing in water but may cause some damage to dry-land paddy and millets.

Sugarcane. Work was continued on the borers of sugarcane and other cereals and also on other agents of damage to these crops which produce effects similar to those caused by the borers. The results obtained up to February 1919 have been incorporated in a paper by the present writer

and Mr. C. C. Ghosh, read at the Third Entomological Meeting, and which is still in the press. Since then considerable further information has been collected and brief notes on the more important points only can be given here; it is intended to write up these further results more fully in a separate paper.

As ascertained by observations extending over the last four years at Pusa, the principal damage to the sugarcane crop occurs in the early stages of its growth in April, May and June, when the climatic conditions at Pusa are characterized by high temperature, very low humidity (at least for the earlier portion of this period) and scantiness or absence of rainfall. The incidence of attack by insect pests is apparently correlated with climatic conditions. Favourable climatic conditions, enabling the crop to grow rapidly, have a great effect in controlling the activities of the pests, the crop in such cases easily outgrowing their attack. But with unfavourable climatic conditions, especially drought and want of moisture in the soil (and it must be remembered that sugarcane is not grown as an irrigated crop in these parts), the insects get the upper hand and owing to want of growth and tillering on the part of the plants the loss caused by their attack is not compensated for, the result being that the percentage of damage becomes very high. In 1920 the sugarcane was planted as usual about the middle of February but, in contrast to previous years, this was done after irrigating the land in order to secure proper moisture. No further irrigation was done and there was no rain worth mentioning until the middle of June. In April the damage in some of the thick canes at Pusa was as high as ten per cent., whilst at Coimbatore and Hebbal (Mysore) similar canes, although planted about the same time as but far more advanced in growth than the canes at Pusa, hardly exhibited any damage except a few occasional dead-hearts here and there. The sugarcanes at Manjri, planted earlier and grown under irrigation, were certainly not as good as the Coimbatore and Hebbal canes either in growth or as regards infestation by borers. The damage about this time

in *juar* (*Andropogon Sorghum*) and maize at Pusa was less than 0·5 per cent.

The correlation between damage to cane by borers (and similar agents) and climatic conditions seems to hold good in the case of all varieties of cane, thick as well as thin, but thin varieties show a greater immunity than thick ones. This will be evident from the following figures showing the percentage of damage in a few varieties of canes grown at Pusa this year:—

Variety		Date	Percentage damage	Date	Percentage damage	Date	Percentage damage	Date	Percentage damage	Date	Percentage damage
Name	Type										
Reora	Very thin	29-III	2·0	7-IV	1·3	26-IV	4·3	14-15-IV	4·7	11-19-VI	13·2
Mancria	Medium.	..		8-IV	3·1	27-IV	10·3	13-V	12·5	5-VI	18·1
Purple Mauritius.	Thick	..		7-IV	5·8	27-IV	10·0	13-V	21·2	6-VI	37·2
Sathi 131 (experimental plot)	Thick	29-III	1·4	8-IV	1·1	25-IV*	0·0	11-12-V	12·4	20-22-VI	29·3
Sathi 131 (Farm plot)	Thick	..		7-IV	2·0	27-IV	0·3	13-V	20·5	7-VI.	25·4

So far as germination was concerned, both the plots of Sathi 131 were very good and ahead of the other varieties, but this advantage was only maintained so long as the soil retained moisture from the irrigation done at the time of planting, and when overtaken by the drought these plots collapsed. All the affected shoots in the experimental plot of Sathi 131 were cut out on 25th April but the subsequent state of infestation shows clearly that this treatment was of no avail to reduce the percentage of attack.

Thin varieties of cane also seem more resistant to drought. In the first week of June the plot of Reora pre-

* All the affected plants were cut out with pruning scissors above the level of the ground so as to cause the least disturbance to the plants.

sented the greenest look of all the varieties, thick as well as thin. Next to this came the following in order of their drought-resisting qualities, so far as could be judged by the eye, Java 36, CO 210, Kussur, Tobe Manjet, CO 213 and CO 214, CO 204, CO 205 and other varieties of thin canes. All the thick varieties, including Sathi 131, Purple Mauritius and D 99 American, exhibited a scorched yellow appearance and in all these plots dead-hearts and dry shoots were prominent. Damage by borers and similar agents increased with the decrease in drought-resisting quality of the different varieties. The first heavy shower of rain fell on 18th June and was followed by other showers. By the end of the year under report (30th June) all the thin varieties had made good progress, but in the case of the thick varieties progress was extremely slow and it seemed that they would take a long time to recover from the effects of the drought. The above facts indicate the suitability of particular varieties of sugarcane to particular areas according to differences in local climatic conditions. Severity or otherwise of attack by borers seems to be intimately connected with this fact. Extended observations over different parts of India are required to throw light on this point and to enable us to arrive at definite conclusions.

Another point which requires similar extended observation is the pest-resisting qualities of different varieties of sugarcane. As a rule, thin varieties seem to be more resistant than thick varieties, but individual varieties, both of thick and thin canes, show different degrees of immunity. At Cuttack in December 1919, Minzo, a thin variety, had all the principal pests, *viz.*, *Scirpophaga xanthogastrella*, *Diatræa auricilia* and *D. venosata*, whilst Sathi, another thin variety, was practically free. Observations made about this time at Pusa, Cuttack and Chinsurah indicated a greater liability to fungal diseases on the part of Purple Mauritius than in the case of other thick varieties. A variety known as B. 3412 was observed to be very badly affected by smut at Chinsurah, whilst all other varieties growing there were completely free from this disease.

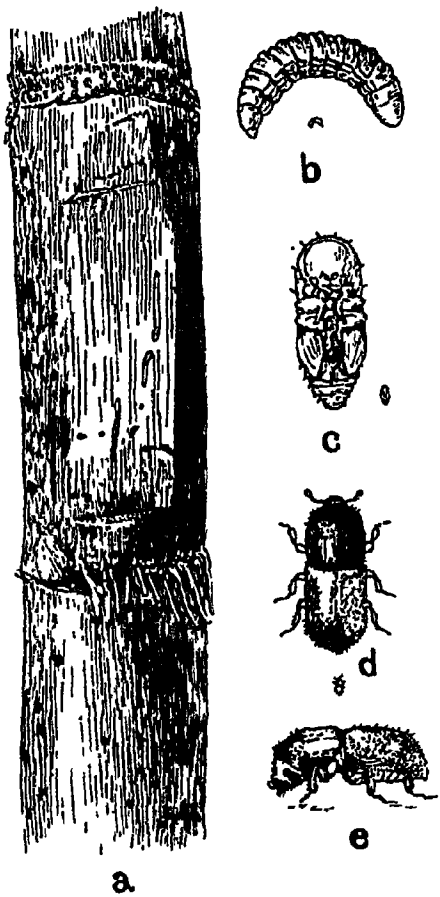
A third point which requires working out is the effect of the presence or absence of alternative foodplants. Instances have been given in the preliminary paper on Cane-borers of such effect in the cases of *Scirpophaga* and the Noctuid larva (C. S. 1666) in sugarcane and of *Chilo simplex* in rice. A notable instance which came under observation this year was the occurrence of *Diatræa venosata* as a regular pest in sugarcane at Cuttack, where no *juar* (*Andropogon Sorghum*) is grown and hardly any *Saccharum spontaneum* is present. At Pusa *D. venosata* occurs very commonly in *S. spontaneum* and in *juar* but rarely in sugarcane.

As a first step in dealing with the control of the borer pests of sugarcane we must take into consideration (1) the suitability or otherwise of the cane itself to the climatic conditions of the locality where it is grown, (2) the habits of the cane, especially its capacity for tillering during the early stages of its growth, as varieties which tiller well show much greater immunity than those in which tillering is poor, (3) the drought-resisting qualities of the canes, especially in the case of tracts where irrigation is not practised, (4) the natural immunity of the canes against pests and diseases, (5) the effect of the presence and absence of alternative foodplants of the different borers, as well as (6) the discrimination and life-histories (in the fullest sense of the word) of the borers themselves. All the above points are not applicable to any one particular locality, as conditions vary locally, but they clearly indicate the need for a whole-time worker, to devote his attention to sugarcane pests only. In order to arrive at successful results in the control of these pests he should include the whole of India within the sphere of his observation and experiment. In my suggestions for expansion of entomological work in India I have already pointed out the necessity for one whole-time expert to work at the question of borers and, when it is realized that a loss of ten per cent. of this crop (and this is probably not an excessive figure for India as a whole) means an annual loss of about three hundred millions of

rupees, it will probably be conceded that there is ample justification for an increase of staff to take up this work.

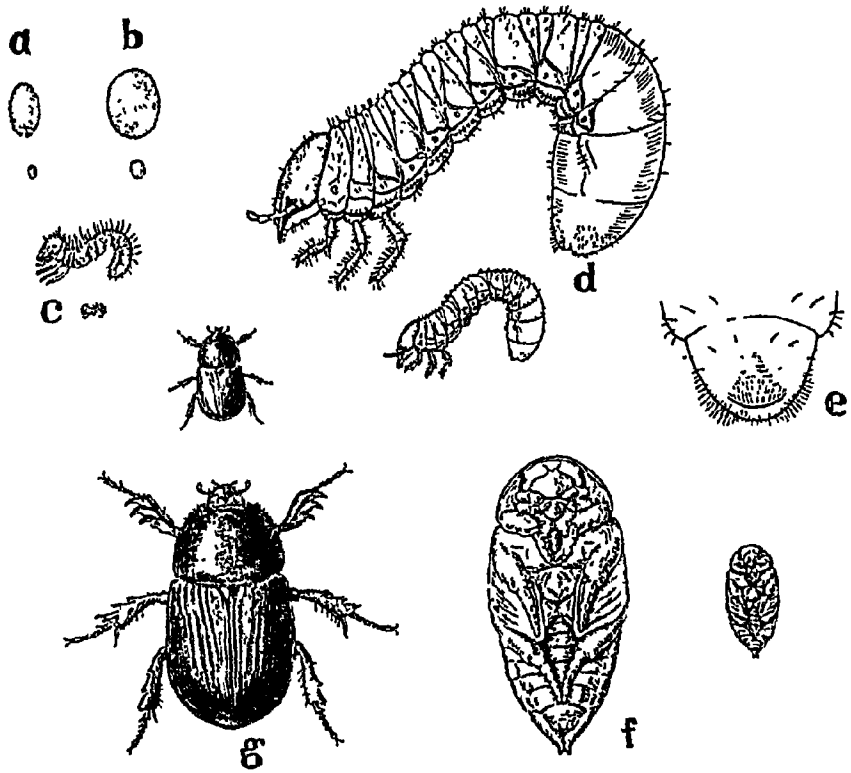
In the course of the last four years during which especial attention has been paid to the insect pests of sugarcane, the Scolytid borer, *Xyleborus perforans*, Woll (Plate IV), has only been observed once, in December 1919, in a variety of cane called B. 147, which was growing on the Chinsurah Farm. This beetle came into prominence over thirty years ago in connection with the destruction of beer-casks shipped to India and was investigated by W. F. H. Blandford, who considered *X. affinis*, attacking sugarcane in the West Indies, as a variety of *X. perforans*. In 1900 a *Xyleborus* was reported as boring sugarcane in Bengal and was considered to be either identical with, or closely allied to, *X. perforans*. In 1892 this beetle formed the subject-matter of a warning letter issued by the Revenue and Agriculture Department of the Government of India, which stated that this pest, notorious in the West Indies as a pest of sugarcane, had already been introduced into India and therefore advised the adoption of measures against its spread. Its occurrence on the Chinsurah Farm, where it was found breeding in three fully-grown canes growing in a clump, the canes being practically dry and showing characteristic holes emitting dust in their basal joints. indicates that this shot-hole borer may perhaps prove to be an occasional pest of cane, possibly more frequently than has been noted by us. In *Indian Museum Notes*, Vol. V, p. 74, it is recorded as having been found in cane in numerous districts in Bihar and Bengal. *X. perforans* is widely distributed in India and Burma and has been recorded as boring in *sal* (*Shorea robusta*), *Anogeissus latifolia* and *Areca catechu*.

Mention was made in last year's Report of three species of Dynastine beetles which occurred on the Kamrup Sugarcane Farm in April-May 1919, *viz.*, *Alissonotum impressicolle* (Plates V and VI), *A. piceum*, and *Heteronychus sublævis*. Attempts were made during the year to work out their full life-histories in the Pusa Insectary with



Xyleborus perforans (C. S. 1970).

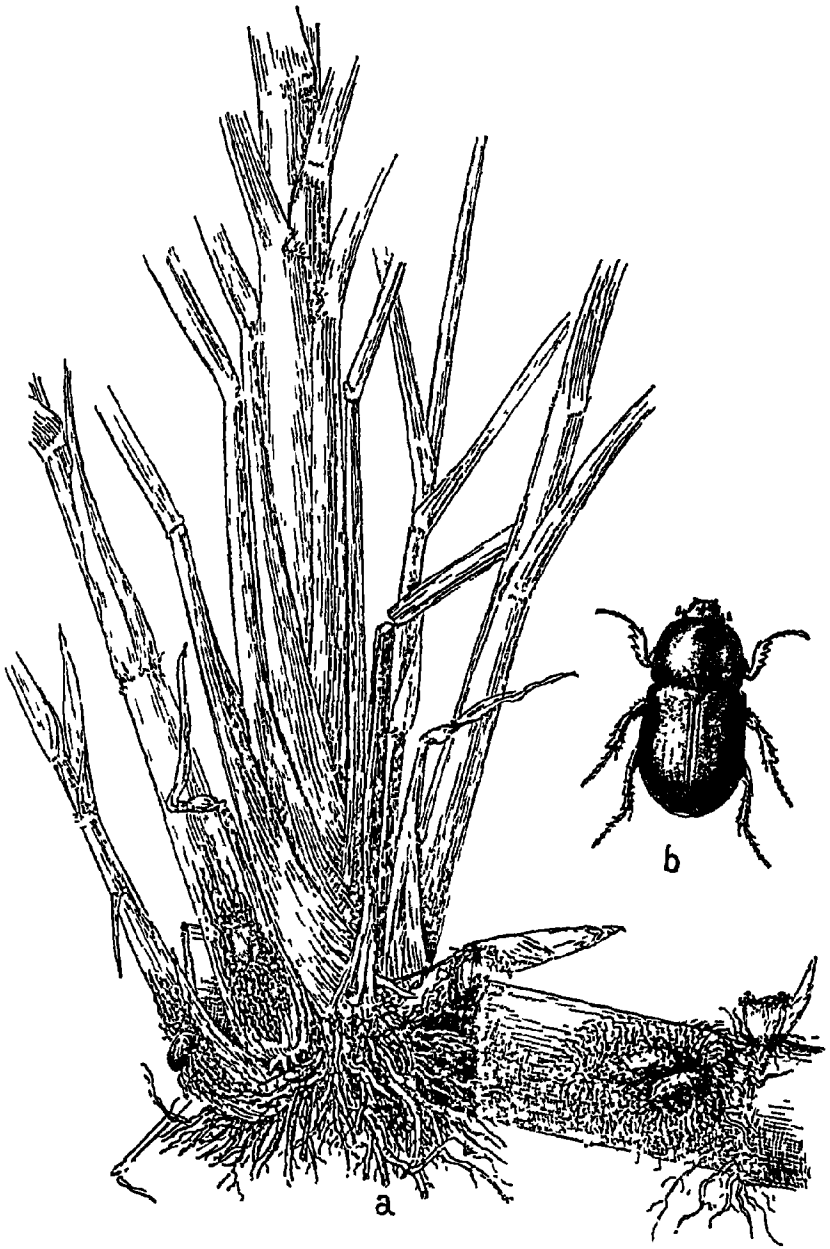
a, Affected sugarcane stem; a slice cut off from a part to show tunnels.
b, Larva (× 9).
c, Pupa (× 9).
d, *e*, Beetle (× 9).
(The smaller figures show the natural sizes.)



Alissonotum impressicolle (C. S. 1949).

a, Egg freshly laid (× 4).
b, Developed egg before hatching (× 4).
c, Newly hatched larva (× 4).
d, Full-grown larva (× 2½).
e, Spines on the ventral surface of posterior extremity of larva (× 4).
f, Pupa (× 2½).
g, Beetle (× 2½).

(The smaller figures show the natural sizes.)



Dynastine Beetles damaging Sugarcane at Kamrup.

a stool of sugarcane shoots with the sett, showing how the beetles bore into the sett and gnaw across shoots, grown as well as newly emerging.

b_1 A beetle (*Alissonotum impressicolle*).

living specimens brought from Kamrup. Success was only obtained with the first-named species. The adult beetles rested in the soil, without taking any food so far as could be observed, until October-November, when eggs were laid. The resultant grubs were reared on roots of maize growing in earth mixed with farmyard manure. The grubs did hardly any damage to the maize plants and seemed to feed mostly on the manure. They fed from November to March and developed into beetles in April. This species has therefore only one generation in the year but, unlike most cockchafers, the grubs are active during the winter. *Alissonotum piceum* most probably has a similar life-history. Only a few beetles were available to start the work and these rested in the adult stage, like those of *A. impressicolle*, one living until October; but no eggs were obtained. Of *Heteronychus sublæris* only one beetle was available for the work, which failed. The adult beetles of these three species were observed to appear at Kamrup in April 1919, and in last year's report it was stated, on the strength of our experience with Scarabaeid beetles generally, that their emergence was delayed owing to the drought which prevailed at Kamrup in February and March. But now it appears, presuming that the beetles reared at Pusa emerged at their natural time, that April may be the normal time for their appearance. According to the observations of Mr. S. R. Gupta, Entomological Assistant, Assam, who has observed it at Kamrup, the adult beetles emerge from the latter part of March until the end of April, and grubs are found from June to January, and pupæ in February; it does not appear, however, that these grubs were actually bred out. As indicated in last year's Report, the beetles occur at Kamrup every year, breeding in large numbers, their grubs finding plenty of food in the rich humus over the extensive areas under wild grasses all around the Sugarcane Farm, but in normal years it is not considered that they are likely to do any extensive damage to sugarcane. This is corroborated by the experience of 1920, when the beetles occurred but did not cause serious damage. With unfavourable climatic conditions, as in

1919, however, they may cause damage unless they can be forestalled by a change in the planting time and also changes in the methods of cultivation so as to avoid the ill effects of drought on the setts lying in the ground. In this connection it may be observed that the whole of the loss sustained at Kamrup in 1919 was not attributable to these beetles; a very careful examination of all the plots, made at the time, showed that the beetles were not responsible for a loss of more than about 20 per cent. of the crop. The failure of setts to sprout owing to unfavourable climatic conditions could not be ascribed to the beetles. Further details of life-histories of these beetles, and especially the question of their normal control by natural enemies, can only be settled by further investigations on the spot.

In March 1920 a few specimens of *Autoserica* sp. were observed gnawing sugarcane shoots at Pusa in the same manner as the Dynastine beetles at Kamrup. It appears that this form of damage is possible by many Scarabæid beetles.

In September 1919 the Entomological Assistant, Assam, collected some grubs of *Anomala dussumieri* (Plate VII. fig. 1) amongst sugarcane roots at Kamrup and sent them to Pusa. The grubs were reared up and were found to hibernate as larvæ, and pupated and emerged as adult beetles in April. Apparently therefore this beetle has only one generation in the year.

Tanymecus hispidus (Curculionidæ) was sent in from Kamrup as attacking young sugarcane shoots in April.

Argyria tumidicostalis, Hmpsn., the borer referred to in the Report for 1917-18 as C. S. 1610, which is one of the most injurious of all the borers in sugarcane, was found in May 1920 in cane at Sadiya, in Upper Assam, all of a number of cane-borers collected there proving to belong to this species, which is now known to occur at Pabna, Jorhat, Dacca and Sadiya. It is to be hoped that it will not be introduced into other parts of India and too great precautions cannot be taken to prevent its transport in canes exported from Assam and Eastern Bengal into other parts of India.

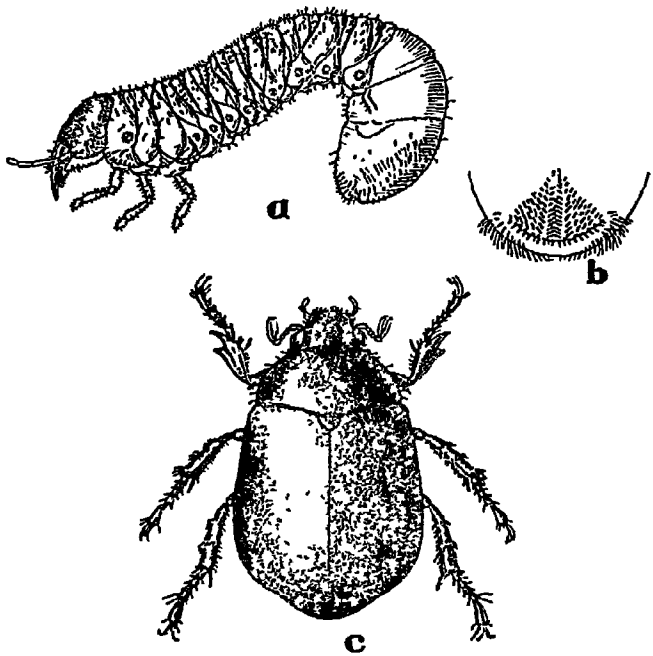


Fig. 1. *Anomala dussumieri* (C. S. 2000).

a, Larva (×2).
b. Spines on the ventral surface of posterior extremity of the larva (×2).
c. Beetle (×2).

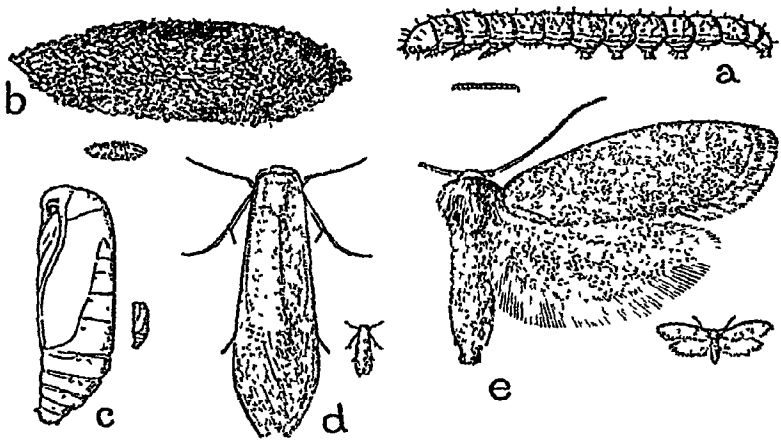


Fig. 2. *Aehroia grisella* (C. S. 1853).

a, Larva, natural size and magnified (×5).
b, Cocoon ,, ,, ,, ,, ,,
c Pupa ,, ,, ,, ,, ,,
d, Moth, ,, ,, ,, ,, ,,
e. Moth, with wings spread, natural size and magnified (×5).

New borers discovered during the year in gramineous and cyperaceous plants included :—

(1) *Hypsotropa tenuinervella*, Rag. (Pyralidæ; C. S. 1920), in stem of *Andropogon squarrosus* at Pusa. This has also been reared from the bulb of *Rosha* grass (*Cymbopogon schœnanthus*) by the Forest Zoologist.

(2) *Crambus corticellus*, Hmpsn. (Pyralidæ; C. S. 2007), in stem of *Scirpus corymbosus* at Nagpur, where it was found by Mr. J. L. Khare.

(3) *Chilo torrentellus*, Meyr. (Pyralidæ; C. S. 2027), in stem of *Saccharum spontaneum* at Pusa. This was reared successfully this year after unsuccessful attempts during the last three years.

(4) *Lychrosis zebrinus* (Cerambycidæ; C. S. 2010), in stem of *Saccharum spontaneum* at Pusa.

The search for alternative foodplants of borers in sugarcane, etc., was continued and the following of importance may be mentioned :—

(1) *Coix lachryma-jobi* var. *aquatica* as a foodplant of *Chilo simplex* on the Farm at Cuttack.

(2) Lemon-grass as a foodplant of *Sesamia inferens* at Pusa.

Brachytrypes portentosus (*achatinus*) (Gryllidæ) did some damage to cane at Pusa in June, cutting the shoots practically level with the ground; but these shoots grew again and practically none of them died.

Mulberry. Frequent reports have been received from Bengal regarding the damage done by *Phenacoccus hirsutus*, the mealy-bug scale-insect which is the cause of "*Tukra.*" Collection of alternative foodplants showed that this scale was very common at Pusa on cotton and guava. From colonies on cotton many adults of the Cecidomyiad fly, *Diadiplosis indica*, Felt, which is predaceous on the egg-masses and adult females, were bred out and liberated to mark the effect of the predator. The Drosophilid fly, *Gitonides perspicax*, Knab, was also found last

year to be one of the predators that keeps this mealy-bug in check to some extent. Hitherto "*Tukra*" has been mostly reported from Bengal but it is possible that it has become widely distributed with mulberry cuttings sent out from infested localities. A Memoir on "*Tukra*" is in course of preparation by Mr. C. S. Misra.

Fruit Pests. Considerable material has been accumulated regarding insect pests of fruit trees, both collected locally and sent in by correspondents all over India seeking for identifications and advice.

Frequent reports were received from correspondents in Tirhut concerning *Batocera rubus*, a Lamiad beetle, which bores in mango trees in its larval stage.

The Cecidomyiad fly which makes galls on mango leaves and which was figured in last year's Report (tab. IX, fig. 2) has been identified by Professor E. P. Felt as *Procontarinia matteiana*, Kieffer and Cecconi.

Chætodacus zonatus (Trypaneidæ) was destructive to Peach fruits at Pusa in May-June. The trees were sprayed, early in the morning each day, with a solution of *gur* and lead arsenate, to destroy the adult female flies, and the attacked fruits were collected and destroyed.

The weevil referred to in last year's Annual Report (page 92) as *Deiradognathus* n. sp., should have been called *Deiradolcus* n. sp., and the necessary corrections should be made.

The undetermined Sphingid found on apple at Shillong and referred to on page 95 of last year's Report has since been determined as *Langia zenzeroides* from specimens reared at Shillong by Major F. B. Scott.

The larva referred to on page 95 of last year's Report, as attacking apple fruits at Ramgarh, has since been reared in some numbers from material kindly supplied by Mr. Johnson, of Ramgarh, and proves to be a Tortricid, which Mr. E. Meyrick has named as *Cacœcia pomivora*, n. sp. Figures of the stages of this insect will be found in Entomological Memoir, Vol. VI, Part 9, tab. LVIII, fig. 1.

Another Tortricid larva has been found to bore into apple fruits at Shillong but can hardly be described as a pest, as it is not common as an apple-borer and seems merely to excavate a small chamber in the core without injuring the pulp of the fruit. This is the larva of *Ulodemis trigrapha*, Meyr., which has also been reared at Shillong from a larva feeding on flowers of *Colquhounia coccinea*. The stages of this species also will be found figured in Entomological Memoir, Vol. VI, Part 9, tab. LVIII, fig. 2.

A new and serious apple-pest was found at Shillong in October 1919 in *Ptochoryctis rosaria*, Meyr., a Xyloryctid moth whose red larva eats the bark of young apple twigs under cover of a silken tubular gallery. This insect has hitherto been known only from Bhutan. From a larva brought to Pusa the moth emerged in March. At Shillong the moths probably appear later in the year, as there seems to be only one brood on apple annually. The stages of this pest also are figured in Entomological Memoir, Vol. VI, Part 9, tab. LXIII, fig. 1.

An interesting and unexpected find on apple at Shillong in May and June, 1920, was *Helopeltis theivora*, the so-called "Tea Mosquito" bug, which in this case was found sucking young shoots of apple.

Specimens of *Brahmina coriacea*, Hope, *Holotrichia* sp., and of a third undetermined Melolonthine beetle were received from the Superintendent of the Kumaon Government Gardens, Ranikhet, as damaging fruit trees. Another Melolonthine, a species of *Microtrichia*, was received from Solan as damaging fruit-trees.

Life-histories of Insects. Besides the various insects named above, more than 150 different lots of insects have been reared during the year and observations made on life-histories and habits. In a Report of this nature it is only possible to mention a few of these even by name.

(1) *Achroia grisella*, Fo. (Galleriadæ) (Plate VII, fig. 2). During the last two years this wax-moth has occurred regularly at Pusa in hives occupied by the Indian Bee

(*Apis indica*) and proved destructive to a number of old stored combs. The caterpillar feeds on wax as well as on the debris that collects in a hive and even nibbles the felt blankets which are kept over the top of the frames. It also feeds on dry propolis, and seems to be a scavenger under natural conditions.

(2) *Chlumetia transversa* (Noctuidæ; C. S. 1960). The larvæ bore into mango shoots but can feed on the leaves also.

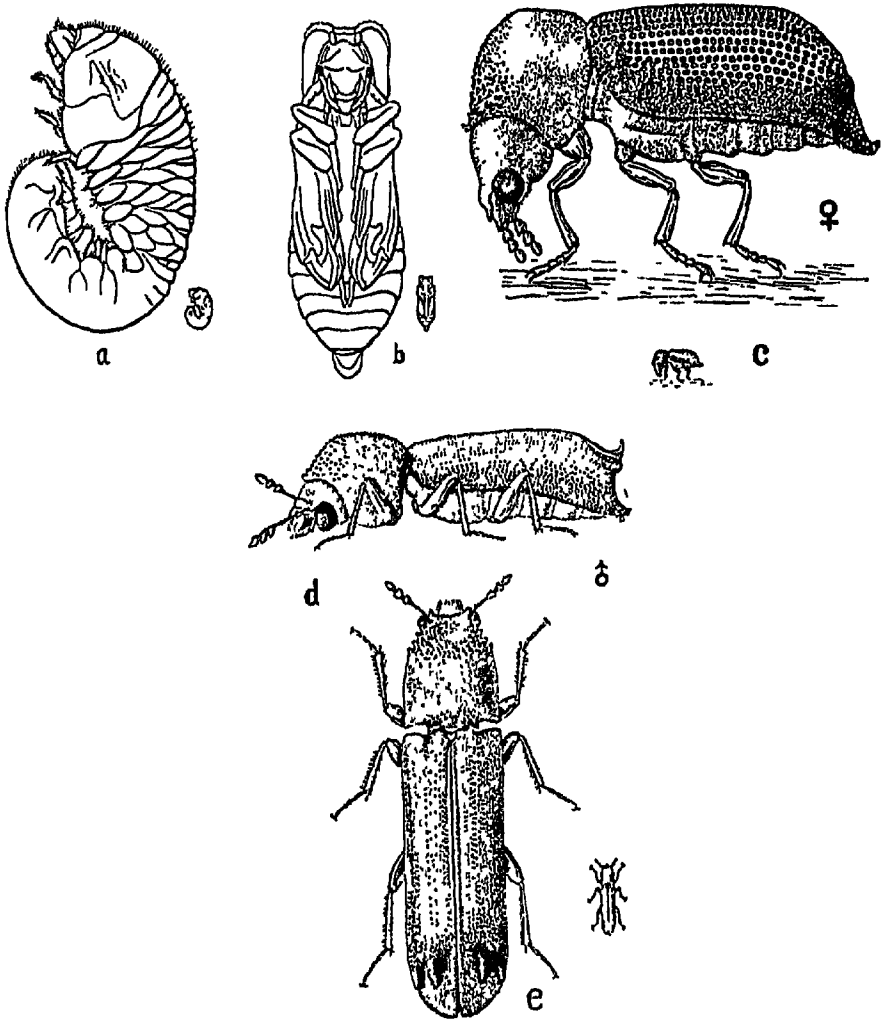
(3) *Camponotus maculatus infuscus* (Formicidæ; C. S. 1983). These black ants were observed to nibble the tender shoots, leaf-stalks and leaves of *brinjal* at Pusa in November. The shoots and leaves so attacked withered. In this way these ants may be a minor pest under favourable conditions.

(4) *Heterobostrychus æqualis* (Bostrychidæ; C. S. 2023) (Plate VIII). This dry-wood borer was received in September from Deolali where bully rafters were being destroyed by it. The grubs fed and developed and emerged as beetles in May-June and the insect seems to have only one generation in the year.

(5) *Sinoxylon anale* (Bostrychidæ) (Plate IX, fig. 1). Specimens of this species also were received from the Assistant Controller of Textile Stores, Bombay, as damaging articles made of wood, *e.g.*, packing cases, handles of brushes, etc.

(6) *Stromatium barbatum* (Cerambycidæ). Eggs of this Longicorn beetle were obtained at Pusa in June 1917 and the larvæ have been feeding now for three years in dry wood, no adults having emerged so far. This larva is a common wood-borer in household furniture and may evidently have a prolonged existence in the larval stage under dry conditions.

(7) *Agrotis ypsilon*, *A. flammatra* and *Euxoa spinifera* occurred in the gram fields at Pusa about March in practically equal numbers. Opportunity was taken to prepare a coloured plate showing the life-history of *Agrotis flammatra*.



Heterobostrychus æqualis (C. S. 1248).

a, Larva, natural size and magnified (× 6½).
b, Pupa, ,, ,, ,, ,, ,,
c, Beetle, female, natural size and magnified (× 6).
d, ,, male, side view (× 6).
e, ,, ,, dorsal view (× 6).

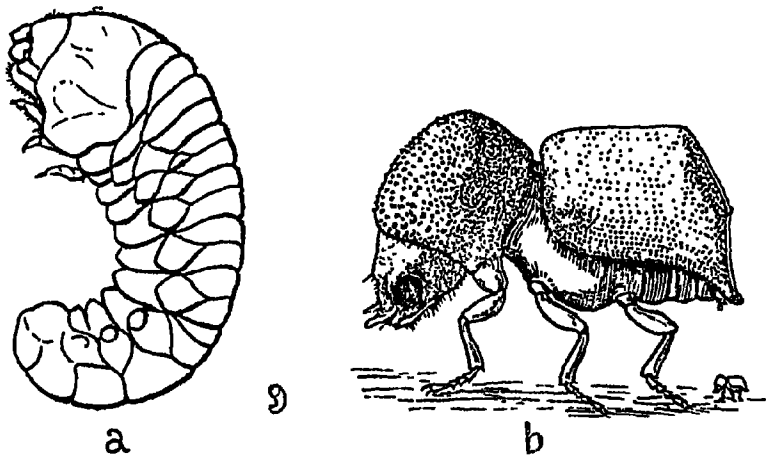
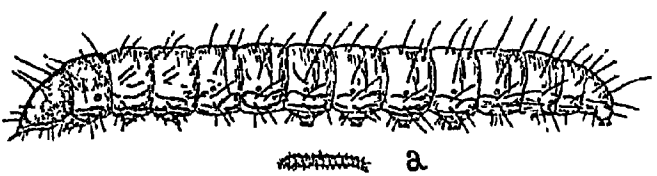


Fig. 1. *Sinoxylon anale* (C. S. 1247).

a, Larva (×14) ; *b*, Beetle (×13).
(The smaller figures show the natural sizes.)



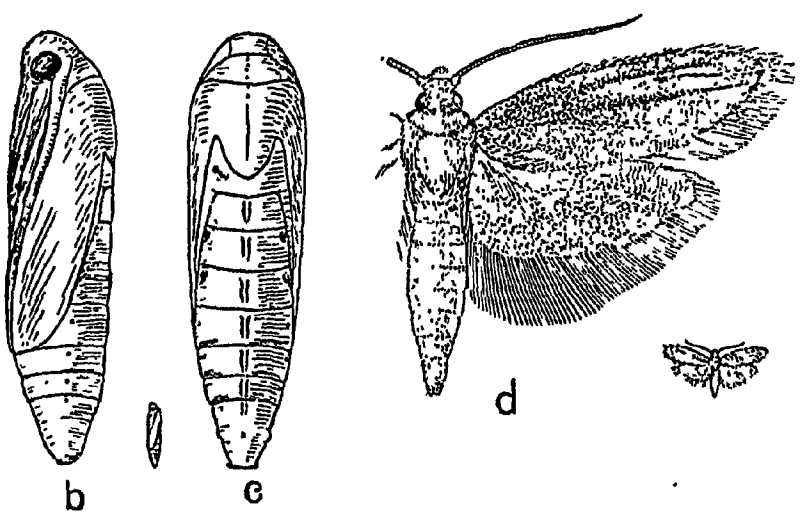
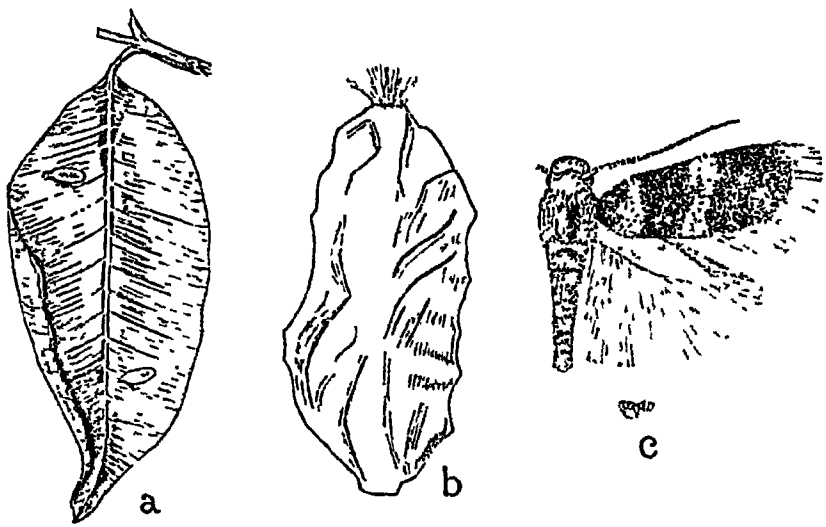


Fig. 2. *Coreyra cephalonica* (C. S. 1979).

a, Caterpillar (×7) ; *b*, *c*, Pupa, lateral and dorsal views (×7) ; *d*, Moth (×7).
(The smaller figures show the natural sizes.)

PLATE X.



Antispila anna (C. S. 1993).

a, Cocoons on leaf.
b, A single cocoon enlarged (× 16).
c, Moth, natural size and enlarged (× 16).

(8) *Juar* (*Andropogon Sorghum*) heads, affected by what is known as *khas* (*i.e.*, sterility) disease in Sind, were received through the Assistant Professor of Entomology at Poona. This disease is believed to be due to a minute Cecidomyiad fly. The affected spikelets do not form any grain and in this particular case many of the aborted growths in the spikelets exhibited a minute hole in their glumes through which the adult insect had apparently emerged. Many of those which did not show such a hole contained a minute red grub, but nothing could be reared out from these. It seems, however, probable that *khas* is due to a Cecidomyiad.

These *juar* heads contained some fully-formed grains, all of which were affected by *Sitotroga cerealella*, a small Gelechiad moth commonly found in granaries. It was, however, impossible to determine whether infection had taken place in the fields.

On the same heads a few caterpillars of *Corcyra cephalonica* (Galleriadæ; C. S. 1979) (Plate IX, fig. 2), another but less injurious granary pest, were found binding the grains together with silk and nibbling them. In this case also it was impossible to determine whether infection had taken place in the fields.

A new species of *Antispila* (Heliozelidæ) was sent in by Mrs. Drake, of Serampore, Bengal, as feeding on *Eugenia jambolana*. Specimens were reared at Pusa from the material received and have been named by Mr. E. Meyrick as *Antispila anna*, n. sp. (Plate X).

Stored Grain Pests. The results of our long series of experiments and the details of the successful method of storage under sand evolved therefrom for the storage of grains have been fully described in a paper, by the present writer and Mr. C. C. Ghosh, in the Proceedings of the Third Entomological Meeting, now in the press. Further work was continued during the year, especially with a view to finding out whether there is any infestation in the fields and, if so, to what extent. For this purpose samples of ripe ears of wheat and barley were collected from various fields on the Farm and are now under observation.

The Board of Agriculture, at their Meeting in December 1919, recommended that the problems of grain storage, with especial reference to the question of damage by insect pests, should be taken up on a large scale and that the staff of the Imperial Entomologist should be increased for this purpose. Proposals for an increased staff have been included in my general proposals for expansion of entomological work in India.

Trogoderma khapra (Dermestidæ) was under observation to ascertain its behaviour and seasonal history at Pusa. A long cycle occupied the whole period from end of June 1919 to March-April 1920. The moist weather during the Rains and the cold weather in the winter retarded the development of the larvæ.

IV. Bees, Lac and Silk.

Bees. No special work was done with bees except carrying on a few colonies of *Apis indica*. A number of improved hives were supplied to inquirers in various Provinces.

As noted above, *Achroia grisella* has now to be added to the list of enemies against which the bee-keeper has to contend.

Proposals have been forwarded for the entry of a bee-keeping expert in order to develop this important branch of Applied Entomology.

Proposals for legislation to restrict the importation of bees into India, with a view to avoid the importation of bee-diseases, are now before the Government of India.

Lac. The emergence of lac larvæ took place at Pusa on 29th October, 1919, and 30th June, 1920, the latter being a very unusually late date. Broodlac was sent to the Government Entomologist, Coimbatore, to the Superintendent of the Agricultural Farm, Ratnagiri, to Gwalior, Lyallpur and Mymensingh. There is a great demand for broodlac, which cannot be met from Pusa.

Mr. C. S. Misra, First Assistant, visited Bhopal State in December 1919 to advise regarding steps to be taken to develop the lac industry there.

The second edition of the Bulletin on Lac Culture in the Plains of India has been exhausted and a third edition is in preparation.

During the year several inquiries were received from Bengal regarding any possible connection between the presence of lac insects and pebrine in silkworms. Specimens of lac insects, received from Malda and Berhampore, did not reveal the presence of any pebrine bodies in the female insects and it is not considered likely that lac insects will be found to be affected by pebrine, but experiments on this line are being started. In this connection it may be noted that both lac and silkworms have been cultivated successfully at Pusa for more than ten years, which seems to dispose of the superstition current in the silkworm rearing districts of Bengal that cocoon crops cannot be successful if lac and silkworms be grown in the same place. The price of lac has advanced so much recently, having gone up to practically ten times the pre-war rates, that the question of lac-production in India has become one of no small economic importance.

Silk. The sericultural establishment is still on a temporary footing which has been extended up to 31st March, 1921. In the meantime experiments on mongrelization of mulberry silkworms have been continued to see whether the mongrel races will continue to give silk superior in quality and quantity to that of the indigenous multivoltine races. It will take some time to arrive at definite conclusions regarding the results of these experiments.

Univoltine races of Bengal, China, Japan and France, and their hybrids, were sent for cold storage to Guindy, Muktesar and Shillong, and were successfully reared at Pusa in October-November and in February-March. Tasar worms were reared in captivity, as well as on trees, and their diseases were studied.

Mulberry silkworm eggs have been supplied to 69 applicants and mulberry seeds and cuttings to 26 applicants, including the Director of Industries, Assam, the Superintendent of the Northern Shan States, the Director of

Agriculture, Bengal, and the Silk Departments of Travancore, Gwalior, Indore and Banganapalle States. Eri silkworm eggs have been supplied to 91, and castor seeds to 5 applicants, including correspondents in Japan, Egypt and England. Three Pusa Twisting Machines were supplied to the Director of Industries, Assam, the Director of Sericulture, Patiala, and the Tyler Weaving School, Shahjahanpur. Two rearers and one reeler were sent to the Superintendent of the Northern Shan States, and one reeler and one rearer to the Assistant Registrar of Co-operative Societies, Lower Burma, to assist the sericultural industry in Burma. Show-cases showing stages in the preparation of eri and mulberry silk were sent to the Deputy Collector on special silk duty, Benares, and to the Curator of the Victoria Museum, Karachi. Numerous inquiries regarding sericulture were dealt with and assistance given to inquirers as far as possible. Silk pieces to the value of Rs. 1,636-6-0 were sold and the proceeds credited to Government and a further Rs. 468-13-0 worth of pieces were made and kept as samples.

Silk exhibits to demonstrate rearing, reeling, twisting, spinning and reversing were sent to Calcutta and Bankipur in connection with the Peace Day Celebration Exhibitions, and a silver medal was awarded by the latter Exhibition. Silk exhibits were also sent to Exhibitions at Unao, Chittagong and Muzaffarpur.

A Bengali version of Bulletin No. 74, on the experiments carried out at Pusa to improve the Silk Industry, was published.

Three students completed the course in sericulture and two others remained under training at the end of the year. Two students from the Sabour Agricultural College were also given some instruction in sericulture.

V. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*, *Agrotis flammatra* and *Cosmophila sabulifera*. A large

number of colour-notes of Indian Odonata was also done. Besides these, about two hundred illustrations in black and white, illustrating the life-histories of various insects reared in the Insectary, were also prepared.

A large number of coloured plates and black and white illustrations are now in the press in connection with the Proceedings of the Third Entomological Meeting and various Memoirs and Bulletins.

VI. Miscellaneous.

Correspondence. A total of 60 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 800 letters were received and 1,088 issued; these numbers show a slight decrease on previous years but are exclusive of a large amount of routine correspondence which takes up a considerable proportion of time which should be devoted to more scientific work.

VII. Insect Survey.

Steady progress has been made in addition to, and arrangement and identification of, the collection which is now a large and important one and continues to expand at a rapid rate. In view of the great value of this collection, both from an economic and systematic point of view, to future students of Indian Entomology, every effort is made for the proper preservation of the large mass of specimens, a task which is by no means easy in a climate such as that of Pusa. This year, for example, owing to the abnormal heat in June, the paraffin-wax in the store-boxes melted. The more irreplaceable portions of the collection and those liable to most damage from mould are therefore being placed in cabinets which are being obtained as rapidly as possible. The staff required for the upkeep (which includes the sorting and identification, as well as the mere preservation, of the *lakhs* of specimens already accumulated and of the thousands received every year) has not been increased since a time, many years ago, when the collection was comparatively quite small; yet this work is

constantly expanding and has already become very heavy, although this is only one branch of the activities of the Entomological Section.

During the year small lots of Ichneumonidæ, Tenthredinidæ and Bees have been returned named after examination by Messrs. Morley, Rohwer and Professor Cockerell respectively. The collection of Hymenoptera is in good order and well named up except for the Braconidæ and Chalcidoidea.

The collection of Coleoptera is in fair order but there is a large amount of unnamed material to be sorted out, named and incorporated. The Bruchidæ sent to Dr. G. A. K. Marshall have been returned, partially named, and a few Curculionidæ have also been received back, named, from Dr. Marshall. Staphylinidæ were received back, named, from Dr. M. Cameron and Carabidæ from Mr. H. E. Andrewes. A small lot of Cicindelidæ sent to Mr. S. W. Kemp was received back unnamed. On receipt of the "Fauna" volume on Hispinæ and Cassidinæ the occasion was taken to revise and name up the whole of the Hispinæ and part of the Cassidinæ. The Paussidæ also have been revised and identified.

The Lepidoptera are in fair order but many accessions remain to be incorporated. The Microlepidoptera collection is contained in cabinets and is by far the largest collection in India; a few specimens were sent to Mr. Meyrick for identification and have been received back named.

The Orthoptera have not been arranged since the late W. F. Kirby identified the earlier collections ten years ago. Since then a mass of material has accumulated and arrangements have now been made for it to be worked over by Mr. Morgan Hebard, of Philadelphia, to whom the collection will be sent for study as soon as the necessary boxes have been received.

The Neuroptera (*sensu antiquo*) also require a good deal of work. The Odonata have been revised during the last year and this portion of the collection has been greatly

extended and is now fairly representative of the Indian Region. Arrangements have been made with Mr. Esben Petersen, of Denmark, to work over the Myrmeleonidæ and allied groups, and these will be sent to him for study.

The small collection of Diptera has been studied and mostly named up by Mr. E. Brunetti so far as concerns the Nematocera and Brachycera, but requires considerable rearrangement which will, it is hoped, be taken up this cold weather.

The Rhynchóta require a whole-time worker to go over the vast accumulation of specimens and reduce them to order. Several consignments of Coccids were sent out for identification during the year.

The *following collections, sent out in previous years,* have not yet been returned :—

(*i*) Histeridæ to Mr. G. Lewis.
(*ii*) Longicorn beetles to Dr. Gahan.
(*iii*) Rhynchota to Mr. W. L. Distant.
(*iv*) Tetriginæ to Dr. J. L. Hancock.
(*v*) Aquatic Rhynchota to the late Mr. C. A. Paiva.
(*vi*) Hispinæ and Cassidinæ to Professor S. Maulik.

Numerous collections of Indian insects have been received and named and returned as far as possible. These included collections sent by the Forest Research Institute, the Provincial Agricultural Departments, the Bombay Natural History Society, and by numerous correspondents.

VIII. Catalogue of Indian Insects.

At the Third Entomological Meeting, held at Pusa in February 1919, it was resolved that there is considerable need of a catalogue of all described Indian Insects with complete references to literature concerning them, especially that published in India, and a Standing Committee was formed to give effect to this resolution. During the past year this work has been pushed on as far as possible and I have brought up to date catalogues of all families of

In addition to the foregoing, the following publications were in the press at the close of the year :—

De, M. N.	The Pusa experiments on the improvement of Mulberry Silkworms. (*Rep. of Proc. of Third Entl. Meeting*, pp. 800-808.)
,,	The best method of eliminating Pebrine from multivoltine Silkworm races in India. (*loc. cit.*, pp. 809-835.)
Fletcher, T. Bainbrigge.	Annotated List of Indian Crop-pests. (*Rep. of Proc. Third Entl. Meeting*, pp. 33-314.)
,,	Life-histories of Indian Microlepidoptera. (*loc. cit.*, pp. 838-857.)
,,	Hints on collecting and preserving Insects. (*loc. cit.*, pp. 936-974.)
,,	Note on a very curious Geometrid larva. (*loc. cit.*, p. 978.)
,,	Indian Epipyropidæ. (*loc. cit.*, pp. 978-982.)
,,	Indian Fossil Insects. (*loc. cit.*, pp. 982-989.)
,,	The desirability and practicability of the preparation and publication of a General Catalogue of all described Indian Insects. (*loc. cit.*, pp. 989-999.)
,,	Note on Plant Imports into India. (*loc. cit.*, pp. 1051-1069.)
,,	Life-histories of Indian Insects: Microlepidoptera. Pterophoridæ. (*Entl. Mem.*, Vol. VI, No. 1.)
,,	Ditto: Carposinidæ, Phaloniadæ, Tortricidæ and Eucosmidæ. (*loc. cit.*, No. 2.)
,,	Ditto: Gelechiadæ. (*loc. cit.*, No. 3.)
,,	Ditto: Cosmopterygidæ, Œcophoridæ, Physoptilidæ, Xyloryctidæ, Stenomidæ and Orneodidæ. (*loc. cit.*, No. 4.)
,,	Ditto: Heliozelidæ, Heliodinidæ, Glyphipterygidæ, Blastobasidæ and Hyponomeutidæ. (*loc. cit.*, No. 5.)
,,	Ditto: Gracillariadæ. (*loc. cit.*, No. 6.)

Fletcher, T. Bainbrigge.	Life-histories of Indian Insects: Epermeniadæ, Plutellidæ and Lyonetiadæ. (*loc. cit.*, No. 7.)
,,	Ditto: Tineidæ and Nepticulidæ. (*loc. cit.*, No. 8.)
,,	Ditto: Appendix. (*loc. cit.*, No. 9.)
Fletcher, T. Bainbrigge and Ghosh, C. C.	Borers in Sugarcane, Rice, etc. (*Rep. of Proc. of Third Entl. Meeting*, pp. 354-418.)
,,	The preservation of wood against Termites. (*loc. cit.*, pp. 705-712.)
,,	Stored Grain Pests. (*loc. cit.*, pp. 712-761.)
,,	Notes on rearing Insects in hot countries. (*loc. cit.*, pp. 875-892.)
Fletcher, T. Bainbrigge and Misra, C. S.	Cotton Bollworms in India. (*loc. cit.*, pp. 443-472.)
Ghosh, C. C. .	A Note on Crabs as pests of Rice. (*Rep. of Proc Third Entl. Meeting*, pp. 680-689.)
,,	Bee-keeping in India. (*loc. cit.*, pp. 770-782.)
,,	Suggestions regarding publication of communications on Indian Insects. (*loc. cit.*, pp. 1034-1042.)
,,	Some aspects of Economic Entomology in India. (*loc. cit.*, pp. 1072-1080.)
Misra, C. S. .	Some Indian Economic Aleyrodidæ. (*Rep. of Proc. Third Entl. Meeting*, pp. 418-433.)
,,	The Rice Leaf-hoppers. (*loc. cit.*, pp. 433-443.)
,,	Some pests of Cotton in North Bihar. (*loc. cit.*, pp. 547-562.)
,,	Index to Indian Fruit-pests. (*loc. cit.*, pp. 564-596.)
,,	*Tukra* disease of Mulberry. (*loc. cit.*, pp. 610-618.)
,,	Lac-culture in India. (*loc. cit.*, pp. 782-800.)

Misra, C. S. . . The Rice Leaf-hoppers. (*Nephotettix bipunctatus, Fabr. and Nephotettix apicalis*, Motsch.) (*Entl. Mem.*, Vol. V, No. 5.)

,, Woolly Aphis. (*Agricl. Journ. India.*)

Ramachandra Rao, Y. *Lantana* Insects in India. (*Rep. of Proc. Third Entl. Meeting*, pp. 671-680.)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(THE LATE F. M. HOWLETT, B.A., F.E.S.)

(Mr. Howlett died at Masuri on 20th August 1920, before writing his Annual Report for the year ended 30th June 1920. The following Report has been written by me from such information as is available.—T. Bainbrigge Fletcher, Imperial Entomologist.)

I. CHARGE AND ESTABLISHMENT.

The Imperial Pathological Entomologist was in charge of the Section during the year. The deputation period under the Indian Research Fund to conduct an investigation into mosquito repellents expired on 24th July 1919. The Imperial Pathological Entomologist left Pusa for Dehra Dun on 4th February 1920, to take charge of the Zoological Branch of the Forest Research Institute and College in addition to his own duties. He was in charge of the Forest Zoologist's office from February to 9th July 1920.

At the request of Mr. H. E. Cross, Camel Specialist, Sohawa, Mr. P. G. Patel has been deputed to work with him on Surra transmission experiments.

Mr. H. N. Sharma was on deputation in connection with the mosquito repellents investigation until 24th July 1919.

M. Shaffi, Fieldman, was on deputation for six months from July 1919 in connection with the Kala-Azar investigation at the Pasteur Institute, Shillong.

II. WORK DONE.

In September 1919 the Imperial Pathological Entomologist took up work on the effect of alkaloidal poisons on rats (undertaken at the suggestion of the Secretary, Indian Research Fund Association), and of X-rays on mosquito-larvæ, in collaboration with Captain Barnard of Colaba

Hospital. He also attempted to discover the insect carrier of a short-period fever which was seriously impairing the efficiency of ships' crews in dock. Experiments were also undertaken at Bombay on ridding railway carriages of bed-bugs, at the request of the Bombay Baroda and Central India Railway.

As arranged by the Hon'ble Member and the Military authorities, the Imperial Pathological Entomologist was directed to resume Surra work and carry out a fly-survey in the Punjab and North-West Frontier Province. He accordingly left Bombay on 25th September 1919 for this work and visited the following places with Messrs. P. G. Patel and S. K. Sen, Assistants, in connection with this survey, *viz.*, Karachi, Jacobabad, Quetta, Lahore, Campbellpur, Basal, Jhalar, Nowshera, Attock, Lawrencepur and Peshawar, and many other small villages. In connection with this work also, an abstract of all reports received from Veterinary Officers with regard to Surra and Horse Flies has been sent to the Director, Veterinary Services in India, Simla.

The Mosquito Campaign on the Pusa Estate was continued throughout the year.

Mr. P. G. Patel, Entomological Assistant, reports as follows on his work during the year :—

"From November 1919 to February 1920 observations were made regarding the activity of the parasites of Tabanidæ.

"Tabanid parasites are in the habit of laying their eggs inside the eggs of *Tabanus*. The egg-laying period of Tabanidæ is (1st brood) from February to April, (2nd brood) from June to July, and (3rd brood) from September to October. There are certain species of *Tabanus* which may be found to lay their eggs either in May or August, but the majority behave in the manner stated above.

"Tabanid parasites have been observed during the whole egg-laying period of Tabanidæ more or less, but no record seems to have been made regarding the behaviour of Taba-

nid parasites during the cold season when the adult Tabanid flies are said to be absent.

"I started collecting egg-masses and examining them for parasites from the beginning of November 1919. On the 3rd November 1919, 33 egg-masses of *Tabanus sanguineus*, 11 egg-masses of *T. albimedius* and 7 of *Chrysops stimulans* were obtained. Nearly half of these eggs were found empty. The egg-masses of larger species, namely *T. albimedius* and *T. sanguineus*, were found infested with parasites, the *Chrysops* eggs being free from the parasite. On 10th November 1919, parasitized egg-masses of *T. albimedius* and *T. crassus* were collected; parasites from the eggs of both these species were seen emerging on 11th and 12th November. Two *T. albimedius* were seen on the river bank on this date. On 15th November 1919, nine egg-masses of *T. sanguineus*, two egg-masses of *T. albimedius*, eleven of *T. bicallosus* and one of *C. stimulans* were collected. Parasites from egg-masses of *T. sanguineus* and *T. albimedius* only were noted to emerge from 17th to 20th November 1919. One adult fly of *Tabanus crassus* was seen at this time. Full-grown larvæ of *T. albimedius* were met with on 21st November 1919. On 24th November 1919, 57 egg-masses of *T. crassus*, 9 unhatched and 48 hatched, were obtained. No adult fly was noted on this date.

"On 27th November 1919, five egg-masses of *Chrysops stimulans* and 2 hatched ones of the same species were obtained. No parasites were found to emerge from these eggs.

"Five egg-masses of *T. albimedius* and 4 old egg-masses of the same species were collected on 28th November 1919. Parasites from these eggs were noted on 30th November 1919. No trace was seen of *T. hilaris*, *T. nemocallosus* or *T. brunnipennis*, which are common during the Rains at Pusa. Full-grown and also young larvæ of *T. albimedius* were obtained on 30th November.

"Three egg-masses of *T. bicallosus* were collected on 30th November. From one of these there emerged four

very small parasites on 2nd December. These parasites were different from those of the larger species of *Tabanus*.

"Parasitized egg-masses of *T. albimedius* and *T. crassus* were obtained on 2nd December.

"Fifty-one egg-masses of *T. crassus* and *T. albimedius* were obtained on 8th December but only six of them were found to contain larvæ and parasites. Parasites began to emerge on 11th December.

"Eggs of *T. sanguineus* and *T. albimedius* collected on 27th November were examined on 8th December and a few were found to harbour parasites in their pupal stage.

"The following egg-masses, both old and fresh, were obtained on 10th December, *viz.*, 54 egg-masses of *T. crassus*, 29 of *T. bicallosus*, 7 of *C. stimulans*, 5 of *T. albimedius*. Of these only unhatched egg-masses of *T. albimedius* and *T. crassus* were found to contain parasites.

"One egg-mass of *T. albimedius* was taken on 11th December; parasites from this egg-mass began to emerge on 13th December; all these parasites were quite active and some of them were seen to be pairing.

"Several egg-masses of spiders, which were found near the egg-masses of *Tabanus*, were also collected to see if the *Tabanus* parasites could be obtained from them. Many spiders' eggs were found infested with hymenopterous parasites, but they were quite different from those of *Tabanus*.

Three egg-masses of *T. albimedius* were obtained on 15th December; and one of these began to hatch larvæ on 17th December; parasites began to emerge on 19th and 20th and were found pairing on 21st December, some of them surviving until 31st December. The total number of parasites which emerged from a single egg-mass of *T. albimedius* was 237, whereas the number of larvæ which emerged from the same egg-mass was 55.

"Thirteen egg-masses of *T. sanguineus* and two of *T. albimedius* were obtained on 18th December and from these parasites were seen to emerge on 23rd December.

"One egg-mass of *T. crassus*, obtained on 23rd November, began to hatch out parasites on 20th December; this egg-mass was kept undisturbed outside the Laboratory in a tank full of water and mud, and the parasites were noticed to survive until 6th January 1920.

"Fresh egg-masses of *T. bicallosus* and *Chrysops* sp. were found on 26th December, but no parasites emerged from these eggs.

"One old egg-mass of *C. stimulans* was examined carefully and was found to contain several parasites of a smaller variety.

"Two very old egg-masses of *T. albimedius*, covered up with a kind of fungus, were obtained on 4th January. One of these was opened up on that date and was found to contain living parasites.

"One egg-mass of *T. sanguineus* was noticed to hatch out parasites on 4th January.

"One egg-mass of *T. albimedius* began to hatch out larvæ on 7th January. The parasites from the same mass emerged on 8th January.

"The total number of parasites which emerged from a single egg-mass of *T. albimedius* was 253 and the number of larvæ which emerged from the same mass was 57.

"One old egg-mass of *C. stimulans* was found to contain parasites (small variety) on 9th January.

"One egg-mass of *T. sanguineus* obtained on 31st December began to hatch out larvæ on 7th January 1920; parasites emerged from this mass on 9th January.

"Several parasites were seen emerging from the egg-masses of *T. albimedius* and *T. crassus* which were collected during the second week of December; on breaking open the egg-masses, the parasites were found alive on 15th January.

"One egg-mass of *T. crassus*, collected on 11th January, was seen hatching out parasites on 18th January.

"One egg-mass of *T. albimedius* type, which was covered up with fungus, began to hatch out parasites on 29th January.

"One freshly-laid egg-mass of *C. stimulans* was found on 8th February.

"Eleven egg-masses of *C. stimulans* were obtained on 15th February; no parasite emerged out of them.

"One adult *T. albimedius* was seen on 20th February.

"Three old egg-masses of *T. crassus* were obtained on 23rd February, but no trace of parasites was seen amongst them.

"Three freshly-laid egg-masses of *T. albimedius* were obtained on 23rd February, and by 27th February 71 parasites emerged from these egg-masses.

"One egg-mass of *T. bicallosus* was observed on 23rd February with one parasite on it; it was kept under observation and seven parasites were found to emerge on 1st March.

"Between 25th and 26th of February 91 egg-masses were collected; they belonged to *T. albimedius, T. virgo, T. bicallosus* and *C. stimulans.*

"Egg-laying of Tabanids was noted in large numbers at Birouli *ghat* where the Estate cows were accustomed to graze.

"Besides the foregoing, work on the parasites of birds was continued at Pusa, the following parasites being obtained from different nests:—(*i*) Two species of blood-sucking midges of the genus *Culicoides* were found in very large numbers in crows' nests. The nest of a crow was invariably found lined with horse hairs and the midges were found inside the hairs quite inflated with blood. The members of the genus *Culicoides* are in the habit of drawing more blood than they can carry on the wing; I have very often marked these flies quite incapable of flying after their meal of blood. About 6 per cent. of the crows' nests were found infested with blood-sucking midges whereas the nests of several other birds which were examined on various occasions did not reveal the presence of these midges. (*ii*) *Squirrel bug:* This bug has proved to suck blood of man, rabbit and goat under Laboratory conditions. It was found mainly inside the nests of squirrels. It belongs to

the family Lygæidæ. No bug of this family has hitherto been recorded to suck blood, although many of them are known to harbour Flagellates, either *Herpetomonas* or *Crithidia*. The life-history of this bug, from egg to egg, has been worked out. (*iii*) A species of *Stomoxys*, apparently *S. oblongata*, was found to breed inside the nest-materials of the *Mynah* and of a kite. (*iv*) *Phlebotomus argentipes*: Flies of this species were observed to emerge out from the nest-materials which were heaped up in a glass aquarium. On examining the nest-materials no larvæ were seen but seven empty pupal cases were met with. Flies of this species were also noticed on several occasions in very large numbers inside the cages of Ostriches and other birds in the Victoria Garden at Bombay. (*v*) *Clinocoris hemipterus* (*Cimex rotundatus*) was obtained from a *Mynah*'s nest, which was situated on a wall of the Tara Stable at Pusa. All the stages of the bug including moults were recovered from the nest. Five pupæ of *Hippobosca maculata* were also found in this nest. (*vi*) A Muscid Fly was found to breed in the nests of a bird called *Siroli* in Bihar. (*vii*) The life-history of *Passeromyia* sp., perhaps *heterochæta* (blood-sucking maggots), has been worked out from egg to egg with a plate. One other kind of blood-sucking maggot has lately been obtained from the nest of a crow at Sohawa."

Mr. S. K. Sen, Entomological Assistant, submits the following report on his work during the year:—

"(1) The experiments started with a view to finding out the correspondence, if any, between the toxicity of salts and their position in the Periodic system were concluded. All the chlorides of Group iii (1), *i.e.*, $CaCl_2$ $BaCl_2$ and $MgCl_2$ behaved similarly, their toxicity being small, but the behaviour of $BaCl_2$ was not quite clear, for in two instances it showed rather pronounced toxicity. $CdCl_2$ which, along with $HgCl_2$ and $ZnCl_2$, falls under Group ii (2), proved to be highly toxic; $ZnCl_2$ had the disadvantage of forming basic precipitate in which condition, however, it appeared highly toxic. With regard to Group i (1), *i.e.*, LiCl, NaCl,

KCl (and NH_4Cl), all, except LiCl, appeared to have very little toxicity, the exceptional behaviour of LiCl being what was expected. It should be mentioned that as some of the chlorides were insoluble in water, attention had to be confined only to those chlorides that entered into true solution with water, and for the study of toxicity equimolecular solutions of the salts were always taken.

" (2) Experiments were continued on the correspondence of the toxicity of volatile organic compounds to their boiling points. Cotton plugs thoroughly soaked in the chemicals were allowed to remain for 48 hours in small phials containing a thin layer of water, care being taken not to bring the plug in contact with the water. Three larvæ of *Stegomyia scutellaris* were then introduced in each of the phials and the time when they died noted. The data so far obtained are scanty and do not warrant a definite conclusion.

" (3) Observations were continued on the comparative behaviour of larvæ and pupæ of mosquitos towards soluble and insoluble salts and poisons. Whereas mosquito larvæ are generally readily killed by minute quantities of HgCl sprinkled in water, the pupæ have almost always been found to resist the action of the salt and to turn into adults. The same was observed with other halogen salts of mercury which were insoluble in water and also some of the insoluble alkaloids. The results obtained seemed to confirm the previous conclusion that the soluble substances operate chiefly cutaneously and the insoluble substances orally ('Effect of mercurous chloride on mosquito larvæ,' read before the Sixth Science Congress).

" (4) In connexion with the Imperial Pathological Entomologist's work on 'Culicifuges' a series of concurrent observations was carried out on the deterrent effects of the following chemicals on *Chætodacus zonatus* with a view to finding out any analogy between the chemotactic reaction of fruit flies and that of mosquitos. The experiment consisted in dissolving varying quantities of methyl eugenol

in spirit, adding fixed quantities of the repellents to the solutions and exposing the mixture in equal quantities. The following is an abridged statement of the average number of flies that came to the repellents (which were tried in various strengths): Cinnamic aldehyde, 0; Turpentine, 38·2; Camphor, 17·4; Napthaline, 22·6; Kerosine, 12·2; Benzine, 26·8; Acetic acid, 19·2; Carbolic acid, 0; Oxalic acid, 11·8; Hydrochloric acid, 10·8; Sulphuric acid, 3·4; Mercuric chloride, 0; Soap (unscented), 12·8; Formalin, 28·6; Amyl acetate, 78; Control (Methyl eugenol only), 33·2. Some chemical change seemed to have taken place in the case of mercuric chloride.

" (5) A further attempt was made to find out the rôle of blood in ovulation in mosquitos. In my previous paper it was stated that eggs were obtained with peptone and in a few cases with milk, but the exceedingly small percentage of successful experiments pointed to some accidental factor being responsible for ovulation. The following were some of the standpoints from which the problem was attacked :—

(*i*) Leucocytes are present in the blood of both vertebrates and invertebrates (which have been found to be attacked by mosquitos). As leucocytes are characterized by amæboid movements and also in some other respects they present a near parallel to *Amœba* and *Euglena*, it was considered probable that the larval habit of eating *Euglena* in water was continued into the adult habit of eating leucocytes (while sucking blood); and if so, *Euglena* might take the place of leucocytes even during the adult stage. But out of the three experiments tried with *Euglena* (sweetened with cane sugar), only in one case were eggs laid by *S. sugens*. The three experiments were continued for three weeks. The result is, however, of interest inasmuch as this is the first instance in which eggs were obtained with a mosquito other than *S. scutellaris* without any meal of blood.

(*ii*) Eggs were obtained in two out of four experiments tried with shed goat's bloods (sweetened with cane sugar). With a view to studying the effects of the different constituents of blood, attempts were made to separate out the serum from the shed blood by means of a centrifuge but this did not succeed, probably on account of failure to prevent coagulation.

(*iii*) Willstätter has recently confirmed the analogy that was believed to exist between chlorophyll and hæmoglobin, but no eggs have hitherto been laid by mosquitos fed with sweetened plant juice.

(*iv*) Mosquitos enclosed with tender plants (from which they could suck the juice if they would) died within four days without ovipositing.

(*v*) In view of Goeldi's opinion that 'honey and other sweet substances have an inhibitory or neutral influence on reproduction,' saccharine and glycerine in various strengths were offered to the mosquitos but they refused even to taste any of the liquids.

" (6) A large number of experiments was carried out on the behaviour of bed-bugs in a varying temperature. Healthy adult bed-bugs were enclosed in very small air-tight tubes designed to contain the least possible amount of air, and the tubes containing the bugs were immersed in water kept at a fixed temperature by means of electric current. The experiments necessitated sustained observation in order to discriminate between apparent and real death. The main issue of the experiments was the establishment of the fact that a two minutes exposure to a temperature of 52°C. is generally sufficient to kill the bed-bug.

" (7) In July 1919 the following were discovered in the hole of an old tree :—

(*i*) A large number of adult sand-flies (*Phlebotomus* sp. near *minutus*),

(*ii*) A few *Culicoides* adults (exceedingly minute species),

(*iii*) One *Ceratopogon* adult and a fairly large number of *Ceratopogon* larvæ, and

(*iv*) Innumerable larvæ of *Culicoides* (which could be seen with difficulty with the naked eye) along with the larvæ of Syrphidæ, of *Psychoda* and of a species of acalyptrate fly.

"Young stages of the sand-fly could nowhere be found. Some *Culicoides* and *Ceratopogon* adults were bred out.

"The *Culicoides* larvæ could never be found in the loose debris within the hole but they lodged themselves in the fungi and other vegetation that had overgrown the inner walls of the hole. The position, shape and depth of the hole afforded ready protection against wind and rain, the source of blood, their food-supply, being probably a large gecko which was found inhabiting it (some of the *Phlebotomus* adults were frequently noticed gorged with blood)."

Mr. H. N. Sharma, Entomological Assistant, submits the following report on his work during the year:—

"On the Imperial Pathological Entomologist receiving orders to investigate Culicifuges for the Military Department, I was directed by him accordingly first to make an inquiry by practical tests into official or other well-known preparations and then into any other substances which might suggest themselves as possibly helpful in securing the ultimate object of the inquiry. This object was to obtain a preparation absolutely effective against mosquitos for a period of not less than three hours.

"According to the above directions the work was arranged under the following heads: —

"(*i*) Severe practical tests of preparation in official or general use; 16 preparations were tested against hungry *Armigeres obturbans*, in cages containing not less than 100 females. Three grams of solid or 2½ ccm. of liquid preparations, covering the hand and the forearm up to an inch

below the elbow, were used in each test. The numbers represent time in minutes before biting began.

"Two lasted for an average of 1½ hours, three for one hour, the rest for less than an hour. In the case of each of the three first-named preparations (Nos. 1, 2 and 3) one mosquito bit before the expiration of 10 minutes during one test, although general biting did not begin till long afterwards and all the mosquitos were hungry. In taking the average figure, these three results have been omitted, as also one test in which Lawson's pomade remained effective for 155 minutes.

"The following is the detailed list and the figures, as given, fairly represent the relative average efficacy of the different preparations:—

(1) Lawson's Mosquito Pomade .	89	Consistency good. Irritation perceptible when fresh but transient.
(2) Cassia, camphor and soft-paraffin (official).	87	Consistency fair. Irritation very perceptible.
(3) Citronella	62	Liquid. Irritation negligible.
(4) Eucarcit	60	Liquid. Irritation negligible.
(5) Paraquit vaseline (Messrs. Thomas).	54	Liquid. Irritation negligible.
(6) Muscatol	42	Liquid. Irritation negligible.
(7) Bamber oil (official) . .	42	Liquid. Irritation negligible.
(8) Mosquito essence (A. and N. Stores).	17	Liquid. Irritation negligible.
(9) Menthol and Turpentine .	17	Liquid. Irritation negligible.
(10) Napthaline (3), soft soap (1) (official).	16	Consistency not very good. Irritation negligible.
(11) N. C. I. Powder (official) .	15	
(12) Kerosine oil	9	
(13) Eucalyptus oil (Kemp) . .	7	
(14) Keating's powder . . .	2	

(15) Vermijelli (official) . . .	1	
(16) Carbolic acid (3), soft soap (1)		Can hardly be tested as it removes the epidermis.

"(*ii*) Similar tests were made with about 140 other substances from which it appears that it is hardly possible to produce a preparation which will remain fully effective for 3 hours.

"A brief list of some of those substances which remain effective for over 9 minutes is given below:—

(1) Cinnamic aldehyde (13), castor oil (100) . .	100
(2) Creosote (1), Kerosine (19)	60
(3) Creosote (5), Castor oil (100)	50
(4) Cresol (5), Castor oil (100)	55
(5) Carbolic acid (5), Castor oil (100) . . .	40
(6) Iodoform (5), Methylated spirit (100) . .	45
(7) Thymol (5), Methylated spirit (100) . .	25
(8) Mustard oil	25
(9) Alcoholic extract of bed bugs	15
(10) Proposote (creosote, phenyl propionate) . .	36
(11) Safrol (50), Castor oil (100)	30
(12) Vinegar	20
(13) Napsal (10), Castor oil (100)	20
(14) Alcoholic ext. of Butch	10
(15) Orthonitrotoluol (10), Castor oil (100) . .	10
(16) Tar oil (5), Castor oil (100)	10

"(*iii*) Tests of repellent power at a distance of 3-4 inches. About 40 substances were tested by a comparative method. These led to the conclusion that (1) the factors concerned with distance repulsion and contact repulsion are probably not identical; (2) neither distance repulsion nor contact repulsion is apparently proportional to the poisonous effect on the mosquito of the vapour of the substance used; (3) mosquitos probably cannot be kept at a distance from the body (by any practically applicable chemical repellent) for any length of time. The following is the list of some of the chemicals tried. They are in order of their merits in each of the three series:—

(1) (*i*) Creosote, Napthaline, (*ii*) Wood oil, (*iii*) Oil of Cassia, (*iv*) Eucalyptus oil, (*v*) Lavender oil,

(*vi*) Citronella oil, (*vii*) Kerosine oil, (*viii*) Formalin, (*ix*) Acetic acid, (*x*) Mustard oil, (*xi*) Tincture of Iodine, (*xii*) Methylated spirit.

(2) (*i*) Phenol, Citronella, Anilin, Thymol, Methylated salicylate, (*ii*) Benzine, Acetic acid, Iodoform, Cresol, Carvacrol and Amyl alcohol.

"2. Electrical X-rays experiment. Mosquito larvæ of various ages, pupæ and imagines were exposed. The effect of the one-minute exposure on the newly hatched (one hour old) larvæ was very prominent, all of them dying within 29 hours. The other stages did not seem affected. This experiment could not be repeated owing to want of facilities.

"3. Observations were made on the effects of depressants on rats Small doses of cocaine mixed up with *bajri* flour, formed into a dough and made into small balls, were offered to *Mus rattus*. The rats were kept singly in cages. At the end of three days the rats developed peculiar symptoms; they grew wild and bit at my hand and also at cage bars and other materials when offered to them. On the eighth day they showed cannibalistic symptoms and destroyed one another.

"4. Mosquito classification work was continued."

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(J. H. WALTON, M.A., B.Sc.)

I. ADMINISTRATION.

Mr. C. M. Hutchinson, C.I.E., Imperial Agricultural Bacteriologist, was in charge of the Section till 10th April, 1920, when he proceeded on eighteen months' combined leave. Proposals for the expansion of the Section received sanction with effect from 26th October, 1919. Under this scheme I was appointed Assistant Bacteriologist from that date.

I was absent on six months' privilege leave from 27th August, 1919, and took over charge of the Section from Mr. Hutchinson on 11th April, 1920.

Mr. N. V. Joshi, B.A., M.Sc., L.Ag., First Assistant, was appointed to act as Assistant Bacteriologist from that date, and Mr. K. S. Viswanatham, B.A., as First Assistant.

II. TRAINING.

Mr. K. Adinarayan Rao, a student from Mysore State, completed his training in agricultural bacteriology on the 5th of April, 1920.

III. SOIL BIOLOGY.

Nitrification. Investigations of the nitrification of cowdung, cow urine, and sheep fold manure were carried out, and a paper on the subject was read at the Indian Science Congress, Nagpur, 1920, by Mr. Joshi. In the case of cowdung it was found that, when added in the fresh state, no nitrate accumulation took place, but when added after storing, under either aerobic or anaerobic conditions, about one-third of its nitrogen was converted into nitrate. The nitrogen of the urine was rapidly converted into nitrate in the soil. The inhibiting effect of excess of carbohydrate

on nitrification was shown by the results obtained when straw was added with the dung or urine. The losses of nitrogen that take place during storage are being further investigated.

Observations of the effect of these manures on the crop yield of oats in pot culture showed the growth of the plant to correspond to the amount of nitrate formed in the nitrification tests, but where a bad physical condition was produced in the soil, the yield was smaller than that expected from consideration of the nitrate figures.

Oats were grown in both pots and plots to which roots, stems, and leaves or the whole plant of *dhaincha* (*Sesbania aculeata*) and cowpea were added. The crops obtained corresponded to the nitrate formation obtained in the laboratory nitrification tests with these plants and their parts.

Study of the wide variations in the accumulation of nitrate during the decomposition of various oil-cakes in Pusa soil tend to the conclusion that they are due to the differences in the relative proportions of carbohydrate and nitrogen in the cakes. The oil content had very slight influence on nitrification and the addition of such materials as cellulose, filter paper, sawdust, starch, cane sugar and glucose to cakes rich in nitrogen, retarded the accumulation of nitrate. Further, in the case of *mahua* (*Bassia latifolia*) cake, no nitrate was found after eight weeks' incubation, except when the cake had previously been fermented.

The nitrogen content of soil under fallow and growing crops was studied. Both nitrate and organic nitrogen contents of the cropped plots were lower than those of fallow plots and the differences were greatest during the period of most active growth of the crop.

Biological analysis of soils. Biological analysis of soil from an abandoned coffee estate in Mysore was carried out.

Nitrogen fixation. Experiments on the effect of the accumulated products of its metabolism on the nitrogen-

fixing power of Azotobacter are being carried out. So far it appears that these products appreciably lower the amount of nitrogen fixation.

Numerous colonies of actinomycetes have invariably been found growing on Ashby's mannite agar plates, inoculated with a dilute soil suspension. Twelve species were examined for nitrogen-fixing power. Only minute gains were recorded, but as this group of organisms is one of the most abundant in soil, their accumulated effect may be of considerable importance, and further investigations of their activities are being taken up.

Seven soils, two from Pusa and five from Mysore, were examined for nitrogen fixation under anaerobic conditions. In liquid culture gains of up to 6·5 mgm. nitrogen per gram dextrose were obtained. Sugarcane megasse has proved an admirable medium for the growth of nitrogen-fixing organisms. After inoculation with mixed cultures of nitrogen-fixing organisms, its nitrogen content rose from 0·27 per cent. to 1·3 per cent. in two months.

IV. Indigo.

Owing to the short rainfall and backward condition of the plant no experiments in manufacture have been carried out since those mentioned in the last report.

Pure cultures of indican hydrolysing bacteria were maintained in the laboratory; the culture In_{10}, the most efficient, isolated three years ago, has lost none of its efficiency in that period.

V. Sterilization of water.

Investigations on this subject were continued, and supplies of the sterilizer "E.C." were manufactured for the weekly disinfection of the wells on the estate.

Two to three per cent. of available chlorine was found to be the maximum possible obtainable with economy of current consumption, and in higher concentrations stability

rapidly diminished. 2·5 per cent. is the optimum aimed at for economy in production and stability of the product.

Stability tests showed that solutions of this strength could be made stable for six weeks at plains temperatures (30° C.) and for six months or more at hill stations (20°—22° C.).

VI. Pebrine.

The work on pebrine was taken over by Dr. A. Pringle Jameson, Protozoologist, who arrived in October 1919. Laboratory accommodation is being provided for him and his staff in this Section.

VII. Programme of work for 1920-21.

1. *Major subjects.*

General biology of soil—

(*a*) Nitrogen fixation, symbiotic and asymbiotic.
(*b*) Bacterial fermentation of organic matter in soils.
(*c*) Influence of bacterial action on availability of phosphates in the soil.

2. *Special enquiries.*

(*a*) Indigo manufacture.
(*b*) Other industrial problems connected with micro-biological activities.

3. *Minor subjects.*

(*a*) Plant pathology.
(*b*) Revision of laboratory methods in soil biology.

VIII. Publications.

Hutchinson, C. M. . Report on Agricultural Bacteriology, 1918-19, for the Board of Scientific Advice.

Hutchinson, C. M. . Pebrine in India. *Mem. of the Dept. of Agri. in India*, Vol. I, No. 8. (*In the press.*)

Joshi, N. V. . . Studies in Biological Decomposition of Cow-dung and Urine in Soil. *Agri. Jour. of India*, Vol. XV, No. 4. (*In the press.*)

Joshi, N. V. . . Studies on the Root Nodule Organism of the Leguminous Plants. *Mem. of the Dept. of Agri. in India*, Vol. I, No. 9. (*In the press.*)

REPORT OF THE PROTOZOOLOGIST.

(A. PRINGLE JAMESON, D.Sc.)

I joined my appointment at Pusa on 17th October, 1919, but considerable inconvenience and delay were experienced in getting the work on silk-worm diseases properly started on account of the extreme slowness with which the apparatus ordered at home was delivered—although ready for dispatch in September 1919, the last consignment was not received until April 1920—and also on account of the lack of assistants, sanction for staff not having been received until May. If it had not been for the kindness of Mr. C. M. Hutchinson and other heads of Sections who lent me sufficient assistance and apparatus to go on with, it would have been practically impossible to have started certain lines of work.

The first silk-worm disease that is being investigated is pebrine. This disease is caused by a very minute protozoan parasite. Sixty years ago the silk industry in Europe was nearly extinguished by it and fears are entertained lest it should assume equally serious proportions in India. The work on this disease was initiated by Mr. Hutchinson and it is being carried on from the point where he left off. It falls naturally into two parts. First the investigation of the life-history of the parasite, *Nosema bombycis*, which causes the disease, and second the investigation of means of controlling the disease. The second line of inquiry is, of course, more or less dependent on the results of the first.

(*a*) *Life-history of the parasite.* Attention is being paid at present to the early stages of the life-history—the behaviour of the spores when introduced into the gut of the silk-worm and the initial attacks of the parasite on the tissues of the host. This work is very difficult to carry on in the hot weather as much of it entails the cutting of extremely thin paraffin wax sections, but already a considerable amount of information has resulted from this line of investigation. It is, however, much too early in the in-

quiry to make any definite pronouncements on the life-history.

(*b*) *Experiments on disease control.* The following are some of the lines of investigation being pursued. Various races of silk-worms are being tested regarding their resistance to disease. Three small *kutcha* rearing houses have been erected and in them experiments on disinfection, length of life of spores, and methods of infection are being conducted. The effect of climatic conditions on disease is being tested. Various rearing methods are being investigated in relation to disease. Certain extremely interesting facts have been brought to light by these experiments, especially with regard to infection of the worms in surroundings highly charged with infectious material and also with regard to the lethal qualities of the disease. But here again the time has not yet come for making any definite statements.

The Government of India having accepted Professor Lefroy's recommendation that a seed supply station be established in Shillong, the matter is now being pushed on. A site for the laboratory buildings has been given by the Governors of the Pasteur Institute and a plot of land for growing mulberry has been selected. The plans and estimates have been drawn up and final sanction is awaited. It is hoped that building operations will be started immediately and the main buildings erected by October. Several hundred mulberry cuttings have been set out in the Shillong Fruit Farm by the Superintendent, Mr. C. H. Holder, to whom thanks are due for his kind assistance.

Programme of work for 1920-21.

The investigation of the life-history of *Nosema bombycis* is being continued. The experiments on disease control, etc., will be carried on and expanded in the light of the results obtained. Experiments on a large scale to test the value of hill amelioration will be started next year, as soon as a station is established in the hills. It is hoped that a beginning will be made with the study of flacherie.

APPENDIX.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(WYNNE SAITH B.A.)

I was placed on special duty for a period of two years with effect from 20th January, 1919, to undertake the collection of all available information in connection with the sugar industry in India, pending a further consideration by the Government of India of the question of establishing a Sugar Bureau. An establishment of two recorders, two clerks, and two typists, with one Superintendent, was sanctioned to enable me to carry on the work, but one of these posts has been vacant for the whole time, the pay and the temporary position not being sufficient to attract a suitable man. The designation of my post was changed to that of the Secretary, Sugar Bureau, with effect from 13th April, 1919.

It will not be out of place here to give a brief history of the successive steps Government have taken to encourage the industry, in the course of which this office came to be created.

Scientific work on the sugarcane crop was started at Manjri in the Bombay Presidency by Mr. Mollison in 1891 and at Samalkot in Madras by Dr. Barber towards the close of the last century. In these two Presidencies some valuable results were obtained. In Bengal and the United Provinces also some work had been done. But it was after the Agricultural Departments were re-organized by Lord Curzon's Government in 1905 that the foundations of the important work being done by Mr. G. Clarke at Shahjahanpur, Mr. Somers Taylor and the late Mr. Woodhouse at Sabour, Mr. Meggitt in Assam, Mr. Clouston in the Central Provinces, and Mr. Robertson Brown at Peshawar in the North-West Frontier Province were laid, while the work already in progress in Madras and Bombay was expanded.

In 1911 Pandit Madan Mohan Malaviya moved a resolution in the Imperial Legislative Council recommending that the duty on imported sugar should be so raised as to make it possible for the indigenous sugar industry to survive the competition to which it was exposed. The late Mr. Gokhale moved an amendment recommending that Government should order an enquiry by a Committee of competent persons into the present condition of the sugar industry in India with a view to ascertaining what action could and should be taken by the State to save the industry from the threatened ruin. He pointed out that there was a great deal that Government could do for the industry even if it did not impose a high protective tariff, in the matter, for instance, of

making the services of expert chemists available, in the matter of the terms on which land might be held, in the matter of irrigation and other facilities and so forth. Government replied that they were alive to the position and were doing their best to improve the methods of cane cultivation and the manufacture of sugar throughout the country. Both the resolution and the amendment were lost. But in November of the same year the question of the Indian sugar industry was considered by the Board of Agriculture in India, and as the result of its recommendations the appointments of a Sugarcane Expert and a Sugar Engineer were sanctioned for a term of years. The headquarters of the former officer were located at Coimbatore in Southern India as canes were found to flower there (this is not the case in Northern India), facilitating thereby the work of raising better varieties of canes by crossing. The Sugar Engineer was stationed in the United Provinces where more than half the total acreage under the crop is grown, his duties being to work out the smallest economical size of a sugar factory suitable for Indian conditions and to advise the public on factory matters. As stated above, both these were on a temporary footing. Nevertheless they marked a stage forward in the policy of developing the Indian sugarcane industry. Since then almost every meeting of the Board has reviewed the work done on this crop at the various experiment stations in the country.

The great European war brought the question of the Empire sugar supply to the forefront. The usual sources of beet sugar supply, Germany, Austria-Hungary and Russia, having been cut off, the world was faced with a serious shortage of sugar, and India in common with the rest had to pay heavily for her imports. It was in these circumstances that the Board of Agriculture met at Poona in December 1917, and the opinion was unanimous that the time was ripe for making a further move in the policy of developing the Indian sugarcane industry. It was the general opinion of the Board that no time should be lost in starting an office where information on all aspects of the Indian sugar industry could be obtained, the information available at that time being scattered in the Secretariats of the various Governments in India, in the records of the late Reporter on Economic Products to the Government of India, and in the offices of the Director-General of Commercial Intelligence, the Government Sugarcane Expert, and the Directors and Deputy Directors of Agriculture in the provinces; this information was to be collected, sifted, reviewed and made available to Government and the public. In view of the prevailing high price of sugar acting as an incentive to putting up factories

in the country it was most desirable that there should be a central organization where reliable information, advice, and assistance could be had.

It will thus be seen that the formation of this office was a natural evolution of the series of steps which the Government had already taken for the improvement of the Indian sugarcane industry. The appointment of the Indian Sugar Committee during the year by the Government of India with the Secretary of State's approval marks a further step in the same direction. It is expected that the Committee will submit definite recommendations as to the Sugar Bureau's constitution and functions, its relation to the provinces, and where it should be located.

The first piece of work undertaken by me was the collection and indexing of all available literature on the subject published in India, sifting the masses of information available in various offices and arranging them in a form convenient for reference. Much progress has been made in this direction, but it was impossible to pay undivided attention to this part of the work as numerous correspondents began to seek advice as soon as the office was established and I was in charge of the duties of the post of Imperial Agriculturist up to 4th January, 1920, and was also appointed a member of the Indian Sugar Committee. Enquiries relating to sugar and sugarcane began also to be transferred to this office by the Agricultural Adviser to the Government of India, the Government Sugarcane Expert, Director-General of Commercial Intelligence, and other officers. The enquiries range from mere requests for statistical information regarding acreage, yield of sugarcane per acre and imports of sugar in India, to varieties of cane, methods of cultivation, manures required, localities where sugar factories can be put up, the machinery required and how to get it, etc.

As it is most essential to have an up-to-date library for a central place of reference like this, steps have been taken to lay the foundations of one which will grow in future. During the year under review 1,448 volumes have been received either by purchase, exchange, or free supply, and they are being continually added to. Scientific and other periodicals bearing on this industry are being subscribed for.

During the year under report I placed myself in touch with almost all the sugar experiment stations of the world, the principal sugar machinery manufacturers in Great Britain and the United States of America. In India I am in touch with all the sugar factories and also with the officers of the provincial Departments of Agriculture connected with sugar and sugarcane.

As mentioned above, I have been appointed a member of the Indian Sugar Committee in addition to my duties as Secretary, Sugar Bureau, with effect from 26th October, 1919. This has given me a further opportunity of getting first hand knowledge of the existing state of the Indian sugar industry.

On 14th May, 1920, I and the Superintendent of my office, Rao Sahib Kasanji D. Naik, proceeded with the Sugar Committee to Java. Here the opportunity was taken of inspecting all the libraries in the experiment stations and in the office of the Secretary to the Java Sugar Syndicate. A great deal of literature was collected, and numerous points on which we were uncertain as to the methods adopted in Java were cleared up. I also brought back with me a collection of the latest Java varieties, including a cane specially recommended for North India by Dr. Jesweit, Sugarcane-breeding Expert, Pasoeroean Experiment Station, which have been sent on to the Coimbatore Cane-breeding Station for planting. I have also arranged by the kindness of Dr. Jesweit, and Dr. Kuyper, officiating Director of the Pasoeroean Experiment Station, to get any crosses done of canes which do not flower in India. It is anticipated that this will be of invaluable assistance to the sugar industry in Bihar, as no crossing has hitherto been possible with the Mungo family which up to date has refused to flower in India.

Publication.

I contributed a paper on "The World's Sugar Supply" which was published as a supplement to the issue of the "Indian Trade Journal," dated 12th March, 1920.

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